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International Experience with Key Program Elements of Industrial Energy Efficiency or Greenhouse Gas Emissions Reduction Target-Setting Programs

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Abstract

Target-setting agreements, also known as voluntary or negotiated agreements, have been used by a number of governments as a mechanism for promoting energy efficiency within the industrial sector. A recent survey of such target-setting agreement programs identified 23 energy efficiency or GHG emissions reduction voluntary agreement programs in 18 countries. International best practice related to target-setting agreement programs calls for establishment of a coordinated set of policies that provide strong economic incentives as well as technical and financial support to participating industries. The key program elements of a target-setting program are the target-setting process, identification of energy-saving technologies and measures using energy-energy efficiency guidebooks and benchmarking as well as by conducting energy-efficiency audits, development of an energy-savings action plan, development and implementation of energy management protocols, development of incentives and supporting policies, monitoring progress toward targets, and program evaluation. This report first provides a description of three key target-setting agreement programs and then describes international experience with the key program elements that comprise such programs using information from the three key target-setting programs as well as from other international programs related to industrial energy efficiency or GHG emissions reductions.

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1. Introduction

Target-setting agreements, also known as voluntary or negotiated agreements, have been used by a number of governments as a mechanism for promoting energy efficiency within the industrial sector. A recent survey of such target-setting agreement programs identified 23 energy efficiency or GHG emissions reduction voluntary agreement programs in 18 countries, including countries in Europe, the U.S., Canada, Australia, New Zealand, Japan, South Korea, and Chinese Taipei (Taiwan).[1]

International best practice related to target-setting agreement programs calls for establishment of a coordinated set of policies that provide strong economic incentives as well as technical and financial support to participating industries. Effective target-setting agreement programs are based on signed, legally-binding agreements with realistic long-term (typically 5-10 year) targets, require facility- or company-level implementation plans for reaching the targets, require annual monitoring and reporting of progress toward the targets, include a real threat of increased government regulation or energy/GHG taxes if targets are not achieved, and provides effective supporting programs to assist industry in reaching the goals outlined in the agreements.

The key program elements of a target-setting program are the target-setting process, identification of energy-saving technologies and measures using energy-efficiency guidebooks and benchmarking as well as by conducting energy-efficiency audits, development of an energy-savings action plan, development and implementation of energy management protocols, development of financial incentives and supporting policies, monitoring progress toward targets, and program evaluation.

This report first provides an overview of three key target-setting agreement programs in the UK, Denmark, and the Netherlands. The report then describes

[1] Price, L., 2005. "Voluntary Agreements for Energy Efficiency or Greenhouse Gas Emissions Reduction in Industry: An Assessment of Programs Around the World," *Proceedings of the 2005 ACEEE Summer Study on Energy Efficiency in Industry*. Washington, DC: American Council for An Energy-Efficient Economy http://ies.lbl.gov/iespubs/58138.pdf

international experience with the key program elements – target-setting, identification of energy-saving technologies and measures, benchmarking, energy management, energy-efficiency audits, energy saving action plans, financial incentives, monitoring and evaluation – that comprise such programs using information from the three key target-setting programs as well as from other international programs related to industrial energy efficiency or GHG emissions reductions.

2. Overview of Key Target-Setting Agreement Programs

Three examples of model target-setting agreement programs are the UK's Climate Change Agreements, Denmark's Energy Efficiency Agreements, and The Netherlands' Long-Term Agreements.

2.1 UK Climate Change Agreements[2]

The UK Climate Change Program was established in 2000 to meet both the country's Kyoto Protocol commitment of a 12.5% reduction in GHG emissions by 2008-2012 relative to 1990 and the domestic goal of a 20% CO_2 emissions reduction relative to 1990 by 2010.[3] A key element of the Climate Change Program is the Climate Change Levy which is an energy tax applied to industry, commerce, agriculture, and the public sector. The revenues from the levy are returned to the taxed sectors through a reduction in the rate of employer's National Insurance Contributions and used to fund programs that provide financial incentives for adoption of energy efficiency and renewable energy.[4] Through participation in the Climate Change Agreements (CCAs), energy-intensive industrial sectors established energy efficiency improvement targets and companies that meet their agreed-upon target are given an 80% discount from the Climate Change Levy. There are 44 sector agreements representing about 5,000 companies and 10,000 facilities. The goal of the CCAs is to reduce carbon dioxide emissions by 2.5 MtC (9.2 $MtCO_2$) by 2010, which is ten times the estimated savings from the Climate Change Levy without the agreements.[5] Companies that exceed their targets will have excess carbon allowances which they are allowed to trade with companies that do not meet their targets through the UK Emissions Trading Scheme.[6]

Table 1 shows that during the first target period (2001-2002) total realized reductions were nearly three times higher than the target for that period.[7] Sectors did better than expected because industry underestimated what they could achieve via energy efficiency. When negotiating the targets, most companies believed that they were already energy-efficient, but when they actually managed energy because of the CCA targets, companies saved more than they thought that they could, especially through improved energy management.[8] Industry realized total reductions that were more than double the

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[2] See: http://www.defra.gov.uk/environment/ccl/index.htm

[3] Department of Environment, Food, and Rural Affairs (DEFRA), 2006. *Climate Change: The UK Programme*. http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/ukccp06-all.pdf

[4] Department of Environment, Food, and Rural Affairs (DEFRA), 2004. Climate Change Agreements: The Climate Change Levy. http://www.defra.gov.uk/environment/ccl/intro.htm

[5] Pender, M., 2004. *UK Climate Change Agreements*. Presentation at the Workshop on Industrial Tax and Fiscal Policies to Promote Energy Efficiency. 24 May 2005. http://ies.lbl.gov/mariepender

[6] Department of Environment, Food, and Rural Affairs (DEFRA), 2005. *UK Emissions Trading Scheme*. http://www.defra.gov.uk/environment/climatechange/trading/uk/index.htm

[7] Pender, M., 2004. *UK Climate Change Agreements*. Presentation at the Workshop on Industrial Tax and Fiscal Policies to Promote Energy Efficiency. 24 May 2005. http://ies.lbl.gov/mariepender

[8] Future Energy Solutions, AEA Technology, 2004. *Climate Change Agreements – Results of the First Target Period Assessment.* Version 1.2.
http://www.defra.gov.uk/environment/climatechange/uk/business/ccl/pdf/cca-aug04.pdf.

target set by the government during the second target period[9,10] and that were nearly double the target during the third target period.[11]

Table 1. Results of the UK Climate Change Agreements: Periods 1-3[12]

Absolute Savings from Baseline	Actual ($MtCO_2$/year)	Target ($MtCO_2$/year)	Actual minus Target ($MtCO_2$/year
Target Period 1 (2001-2002)	16.4	6.0	10.4
Target Period 2 (2003-2004)	14.4	5.5	8.9
Target Period 3 (2005-2006)	16.4	9.1	7.3

2.2 Denmark – Energy Efficiency Agreements

In 1990, the Danish Parliament established an ambitious target to reduce its national CO_2 emissions by 20% by 2005, relative to the 1988 level. Under the Kyoto Protocol, a new target was set to reduce GHG emissions by 21% below 1990 levels by 2008-2012. To reach its climate goals, Denmark has undertaken a succession of integrated GHG emissions reduction strategies.

In 1996, a system of voluntary Energy Efficiency Agreements was introduced. The revenues raised from the tax applied to industry were returned to the business sector largely through reductions in labor market contributions and grants for energy efficiency investments. The Energy Efficiency Agreements, signed by individual companies or associations of companies with the Danish Energy Agency, were made for periods of three years. Between 1996 and 2001, approximately 300 companies entered into such agreements, representing 60% of total industrial energy consumption in Denmark.[13] Under the agreements, the companies were required to implement all "profitable" energy savings projects, which were defined as projects with payback periods of up to four years, as identified in an energy audit or through internal investigations. In addition, companies were required to introduce energy management and to ensure that investments in new equipment were energy efficient. Subsidies were provided for up to 30-50% of the cost of

[9] Department of Environment, Food, and Rural Affairs (DEFRA), 2005. *News Release: Industry Beats CO2 Reduction Targets.* 21 July 2005. http://www.defra.gov.uk/news/2005/050721b.htm

[10] Future Energy Solutions, AEA Technology, 2005. *Climate Change Agreements – Results of the Second Target Period Assessment.* Version 1.
http://www.defra.gov.uk/environment/climatechange/uk/business/ccl/pdf/cca-jul05.pdf

[11] Department of Environment, Food, and Rural Affairs (DEFRA), 2007. *Climate Change Agreements: Results of the Third Target Period Assessment.*
http://www.defra.gov.uk/environment/climatechange/uk/business/ccl/pdf/cca-jul07.pdf

[12] Department of Environment, Food, and Rural Affairs (DEFRA), 2007. *Climate Change Agreements: Results of the Third Target Period Assessment.*
http://www.defra.gov.uk/environment/climatechange/uk/business/ccl/pdf/cca-jul07.pdf
Note that adjustments to the target have been made due to significant changes in the steel sector; see referenced material for details.

[13] Hansen, M.D., 2001. "The Danish Experience with Efficiency Improvement in Industrial and Commercial Sectors," *Workshop on Best Practices in Policies and Measures*, 8-10 October 2001, Copenhagen. http://unfccc.int/files/meetings/workshops/other_meetings/application/pdf/hansen.pdf

energy-efficient investments.[14, 15] In 1999, the Ministry of Finance concluded that the business energy and CO_2 taxes created a substantial environmental effect in an economically efficient way, while taking international competitiveness into proper consideration.[16] The Energy Efficiency Agreements led to a reduction in energy consumption of 9%,[17] reduced energy consumption by 2 to 4% of total energy consumption per agreement after three years (thereby exceeding business-as-usual by about 1% per year),[18] sped up the process of adopting energy-efficiency measures,[19] and led companies to take energy management more seriously.[20]

2.3. Netherlands – Long-Term Agreements and Energy Benchmarking Covenants

In the Long-Term Agreements (LTAs) in The Netherlands, voluntary agreements between the Dutch Ministries and industrial sectors consuming more than 1 petajoule (PJ) per year were established in support of achieving an overall national energy-efficiency improvement target of a 20% reduction in energy efficiency between 1989 and 2000. The agreements were negotiated between government and industry associations over a two-year period and signed in 1992. Each industry association signed an agreement with the Dutch Ministry of Economic Affairs committing that industry to achieve specific energy efficiency improvements by 2000. In total, 29 agreements were signed involving about 1000 industrial companies and representing about 90% of industrial primary energy consumption in The Netherlands. The average target was a 20% increase in energy efficiency over 1989 levels by 2000. The LTA program ended in 2000 with an average improvement in energy efficiency of 22.3% over the program period (see Figures 1 and 2).[21,22,23]

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[14] Bjørner, T.B. and Jensen, H.H., 2000. *Industrial Energy Demand and the Effect of Taxes, Agreements and Subsidies.* Copenhagen: AKF Forlaget. http://www.akf.dk/udgivelser/2000/pdf/industrial_energy_demand.pdf/

[15] Johannsen, K.S., 2002. "Combining Voluntary Agreements and Taxes – An Evaluation of the Danish Agreement Scheme on Energy Efficiency in Industry," Journal of Cleaner Production 10: 129-141.

[16] Finansministeriet, 1999. *Evaluering af grønne afgifter og erhvervene*. Schultz Forlag.

[17] Bjørner, T.B. and Jensen, H.H., 2000. *Industrial Energy Demand and the Effect of Taxes, Agreements and Subsidies.* Copenhagen: AKF Forlaget. http://www.akf.dk/udgivelser/2000/pdf/industrial_energy_demand.pdf/

[18] Togeby, M., K. Johannsen, C. Ingrslev, K. Thingvad, and J. Madsen, 1999. "Evaluations of the Danish Agreement System," *Proceedings of the 1999 American Council for an Energy-Efficient Economy Summer Study on Energy Efficiency in Industry*. Washington, DC: ACEEE.

[19] Krarup, S., M. Togeby, and K. Johannsen, 1997. *De første aftaler om energieffektivisering – erfaringer fra 30 aftaler indgået i 1996*. Working paper. Copenhagen: AKF Forlaget. http://www.akf.dk/udgivelser_en/container/udgivelse_222/

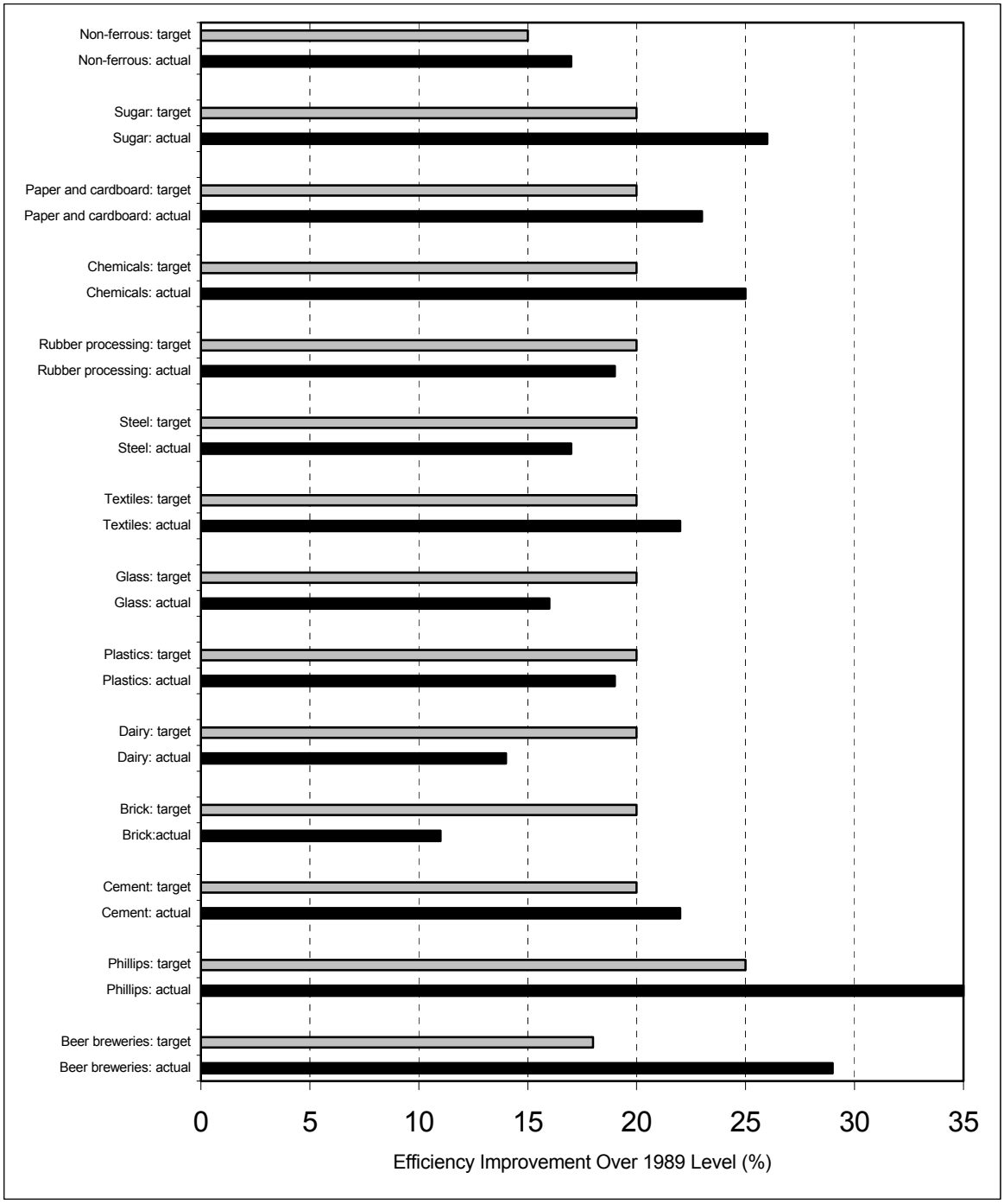
[20] Johannsen K. and Larsen, A., 2000. *Voluntary Agreements – Implementation and Efficiency. The Danish Country Study. Case Studies in the Sectors of Paper and Milk Condensing*. Copenhagen: AKF Forlaget. http://www.akf.dk/vaie_en/papers/taskc_danish.pdf/

[21] Nuijen, W., 1998. "Long Term Agreements on Energy Efficiency in Industry," in Martin et al., (eds.) *Industrial Energy Efficiency Policies: Understanding Success and Failure*, Proceedings of a Workshop Organized by the International Network for Energy Demand Analysis in the Industrial Sector. Utrecht, The Netherlands, June 11-12, 1998. (LBNL-42368). http://ies.lbl.gov/iespubs/42368.pdf

[22] Kerssemeeckers, M., 2002. *The Dutch Long-Term Voluntary Agreements on Energy Efficiency Improvement in Industry.* Utrecht, The Netherlands: Ecofys

[23] Ministry of Economic Affairs, 2001. *Long-Term Agreements on Energy Efficiency: Results of LTA1 to Year-End 2000*. The Hague: Ministry of Economic Affairs. http://www.senternovem.nl/mmfiles/8EZ--

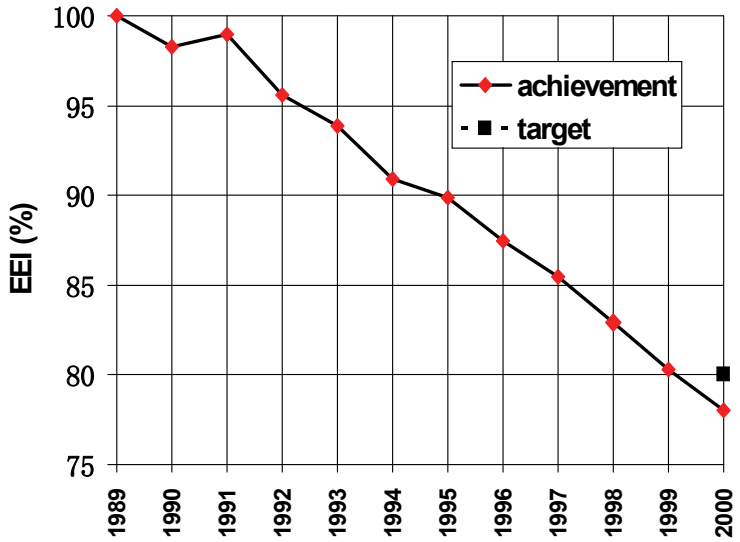
Figure 1. 2000 Target and Actual Energy Efficiency Improvement in Selected Industries in The Netherlands Compared to 1989 Baseline (%).[24]



02%2E01%20LTA%20results%202000%20part1_tcm24-198282.pdf,
http://www.senternovem.nl/mmfiles/8EZ--02%2E01%20LTA%20results%202000%20part2_tcm24-198283.pdf,
http://www.senternovem.nl/mmfiles/8EZ--02%2E01%20LTA%20results%202000%20part3_tcm24-198284.pdf

[24] Nuijen, W. and Booij, M., 2002. *Experiences with Long Term Agreements on Energy Efficiency and an Outlook to Policy for the Next 10 Years*. Utrecht, The Netherlands: NOVEM http://ies.lbl.gov/iespubs/lta_experiences.pdf.

Figure 2. Energy Efficiency Improvement Results of the Long-Term Agreements in The Netherlands, 1989-2000.



Recent evaluations of the LTAs found that the agreements helped industries to focus attention on energy efficiency and find low-cost options within commonly used investment criteria.[25,] Although the agreements themselves proved to be successful and cost-effective, various support measures were implemented within the system of voluntary agreements.[26] It is difficult to attribute the energy savings to a specific policy instrument; rather, it is the result of a comprehensive effort to increase implementation and development of energy-efficient practices and technologies in industry by removing or reducing barriers. This emphasizes the importance of offering a package of measures that includes financial, technical, and informational assistance instead of a set of individual measures. A recent evaluation calculated that the cost of the LTAs was about $10 per tonne of CO_2 reduced.[27]

Following the LTAs, the Dutch government established a second LTA program – referred to as the Long-Term Agreements 2 (LTA2) program – for smaller businesses and industry. The LTA2 program, which runs from 2001 to 2012, differs from the first LTAs in that the LTAs were a voluntary agreement between Ministries and sectors, while the LTA2s are an agreement between individual businesses, sectors, and competent

25 Korevaar, E., J. Farla, K. Blok and K. Schulte Fischedick, 1997. *A Preliminary Analysis of the Dutch Voluntary Agreements on Energy Efficiency Improvement*, The Energy Efficiency Challenge, Proc. 1997 ECEEE Summer Study, Splinderuv Mlyn, Czech Republic, 9-14 June 1997.

26 Rietbergen, M., J. Farla, and K. Blok, 1998. "Quantitative Evaluation of Voluntary Agreements on Energy Efficiency," in Martin et al., (eds.) *Industrial Energy Efficiency Policies: Understanding Success and Failure.* Proceedings of a Workshop Organized by the International Network for Energy Demand Analysis in the Industrial Sector. Utrecht, The Netherlands, June 11-12, 1998 (LBNL-42368), http://ies.lbl.gov/iespubs/42368.pdf

27 Blok, K., H.L.F. de Groot, E.E.M. Luiten, and M.G. Rietbergen, 2004. *The Effectiveness of Policy Instruments for Energy-Efficiency Improvements in Firms: The Dutch Experience*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

authorities. The energy-efficiency target for a business or sector is set based on the results of an independent research assessment. A 2005 evaluation of the program indicated that 34 sectors were participating, representing a total of 906 companies. The industrial companies participating in this program achieved an energy efficiency improvement of 19.1% compared to 1998 (the reference year).[28] The energy efficiency improvements made by these companies during the 2001-2004 period were equivalent to an emissions reduction of 2.8 MtCO2.[29]

In addition to the LTA2 program, the Dutch government also established the Energy Benchmark Covenant program for large energy-intensive industries.[30] Signatories to the covenant are the Ministry of Economic Affairs, the Ministry of Housing, Spatial Planning and the Environment, the Inter-Provincial Consultative Forum on behalf of the provinces, a national-level industrial and employer association and various industrial sectoral associations. Industrial companies must consume at least 0.5 petajoules of energy per year to join the agreement. Industries pledge to be among the world's leaders in energy efficiency by 2012 at the latest. The government ensures that the participating industries are not subject to additional government policies regulating CO_2 emissions reductions or energy conservation and that new energy taxes will not be levied on the participating industries. The participating industries establish an energy efficiency plan describing how they will meet their target. Six power generating companies and 97 industrial companies comprising a total of 232 facilities have signed the Benchmarking Covenant. These facilities have an aggregate energy consumption of 1,060 PJ and represent 94% of the industrial sector energy consumption and 100% of the electric sector energy consumption in the country.[31] Total expected savings from this program are 95 PJ in 2012, avoiding approximately 5.8 $MtCO_2$.[32]

[28] SenterNovem, 2006. *Long Term Agreements on Energy Efficiency in The Netherlands: Results for 2005*. http://www.senternovem.nl/mmfiles/2MJAF0638_LTA_Results_for_2005_UK_tcm24-209539.pdf

[29] SenterNovem, 2005. *Long Term Agreements on Energy Efficiency in The Netherlands: Results for 2004*. http://www.senternovem.nl/mmfiles/3MJAF05.03%20LTA%20Results%20for%202004_tcm24-175780.pdf

[30] http://www.benchmarking-energie.nl/

[31] Commissie Benchmarking, 2002. *Benchmarking Covenant: High Degree of Industrial Participation Interim Report as at February 2002.*

http://www.benchmarking-energie.nl/pdf_files/Benchmarking%20Covenant%20uka.doc

[32] Commissie Benchmarking 2004. *Rapportage Commissie Benchmarking over monitoringjaar 2004*. http://www.benchmarking-energie.nl/pdf_files/Def.Jaarrap2005%201.doc

3. Target-Setting Process

Typically, the process for setting energy efficiency or GHG emission reduction targets involves making a preliminary assessment of the energy efficiency or GHG mitigation potential of each industrial facility which includes an inventory of economically-viable measures that could be implemented. These assessments, which can be made by the company themselves or by an independent third party, are then provided to the government and form the basis for discussions and negotiations related to target-setting between the industries and the government.

In the UK, the process for setting the Climate Change Agreement targets began with information-gathering on the part of the government. The government obtained information regarding energy efficiency potential in energy-intensive industries through the Energy Efficiency Best Practices Program which produced good practice guides and case studies, new practice case studies, and information on future practices[33] as well as through a report prepared by ETSU (now AEA Energy & Environment) on projections of industrial sector carbon dioxide emissions under a business-as-usual scenario as well as two scenarios that included all cost-effective and all technically-possible technologies.[34] Then, for the ten largest energy-consuming sectors, individual companies made estimates of what energy efficiency improvements they could make based on an assessment of their potential and provided this information to their trade associations. The starting point for the major industries was studies establishing what would be expected under business-as-usual and what could be achieved if all cost-effective measures were adopted, which was based on recent history of efficiency measures, rates of technology uptake, expected growth rates, and investment plans.

Once this information was gathered, negotiations took place with each sector. The sector offered a target for the whole sector to the government. Negotiation then drew the process forward, with government often requiring the industry sector to improve their offer to a more challenging level, based on information on cost effective processes and general standards of energy management in the sector.[35]

For the Long-Term Agreements (LTAs) in The Netherlands, voluntary agreements between the Dutch Ministries and industrial sectors consuming more than 1 petajoule (PJ) per year were established in support of achieving an overall national energy-efficiency improvement target of a 20% reduction in energy efficiency between 1989 and 2000. The targets were divided among the various industrial sectors with most industries also adopting a target of 20% reduction, but some establishing different targets based on assessments of their energy-efficiency potential. For example, the petroleum

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[33] Shock, R., 2000. *The UK Energy Efficiency Best Practice Programme*. http://www.un.org/events/energy2000/speaker/shock/shock.ppt.

34 ETSU, 1999. *Industrial Sector Carbon Dioxide Emissions: Projections and Indications for the UK, 1990 – 2020*. See discussion of this report in ETSU, AEA Technology, 2001. *Climate Change Agreements – Sectoral Energy Efficiency Targets* (version 2). http://www.defra.gov.uk/environment/ccl/pdf/etsu-analysis.pdf

[35] Price, L., Blok, K., Nuijen, W., and Pender, M., 2005. "Setting Voluntary Agreement Targets," presentation at the *Workshop on Energy Efficiency Agreements*, Beijing, November 15, 2005.

refining industry's overall target was a 10% reduction, while the target for Philips Lighting was a 25% reduction.

The process for establishing the industrial sector targets began with a preliminary assessment of the energy efficiency potential of the sector by the industry. A quantified target was then set for the improvement of energy efficiency in the sector, based on the outcome of the study. A Long-Term Plan (LTP) described how the sector planned to realize its target. The LTAs include commitments for individual companies, such as the preparation of an energy conservation plan (ECP) and annual monitoring of developments in energy efficiency, expressed using an energy efficiency index (EEI). Then NOVEM,[36] the Dutch Agency for Energy and Environment, established an inventory of economically-viable measures that could be implemented by the companies in each industrial sector and based on this inventory set a target for energy efficiency improvement for each sector.[37] The LTA for the period 1989-2000 met its target and more with an improvement of the average energy efficiency of 22.3%.

The Dutch Benchmarking Covenants, which began in 2001, use a benchmarking approach for target-setting. Using this approach, the participating company hires an expert third party to perform a study of the international best practice in terms of energy efficiency for all of its processing plants once every four years. On the basis of the information provided by the studies, the total target for energy efficiency improvements for the entire facility is determined using the weighted average of the calculated energy efficiency figures. The results of the international best practice benchmarking study are then sent to the independent authority which verifies the accuracy and completeness of the expert third party's methods and results of the study.[38]

In Japan's Keidanren Voluntary Action Plan on the Environment, which commits to stabilizing greenhouse gas emissions of Keidanren members at 1990 levels by 2010, numerical savings targets were set voluntarily be 38 sectors in 1997. The number of sectors has since grown to 58, including 35 from industrial and energy-converting sectors. Individual firms commit to targets within their industrial associations but these are not legally binding. Individual targets are set following technical and economic analyses of energy-saving technologies and potential. Firms have chosen absolute targets, intensity targets, and targets for improving the energy efficiency of products. Of the 35 industrial sectors, 12 committed to absolute CO_2 emissions reduction targets, 9 to CO_2 intensity reduction targets, 5 to absolute energy use reduction targets, and 15 to energy intensity targets.[39]

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[36] Now SenterNovem.

[37] Nuijen, W. and Booij, M., 2002. *Experiences with Long-Term Agreements on Energy Efficiency and An Outlook to Policy for the Next 10 Years*. Utrecht, The Netherlands: NOVEM. http://www.senternovem.nl/mmfiles/lta_experiences_report_tcm24-171835.pdf

[38] Commissie Benchmarking, 1999. *Energy Efficiency Benchmarking Covenant*. http://www.benchmarking-energie.nl/pdf_files/covteng.pdf

[39] Wakabayashi, M. and Sugiyama, T., 2007. "Japan's Keidanren Voluntary Action Plan for the Environment," in Morgenstern, R.D. and Pizer, W.A., eds, *Reality Check: The Nature and Performance of Voluntary Environmental Programs in the United States, Europe, and Japan*. Washington DC: Resources for the Future.

4. Identification of Energy-Saving Technologies and Measures

Countries with strong industrial energy efficiency programs provide information on energy efficiency opportunities through a variety of technical information sources including energy efficiency databases, software tools, and industry- or technology-specific energy efficiency reports.[40]

The U.S. Department of Energy's (USDOE's) Industrial Technologies Program provides many software tools, such as MotorMaster, for assessing energy efficiency of motors, pumps, compressed air systems, process heating and steam systems.[41] Fact sheets or brochures contain information on energy efficiency methods, technologies, processes, systems and programs, or provide results from demonstration projects or annual reports. The USDOE also provides case studies that describe energy-efficiency demonstration projects in operating industrial facilities in the aluminium, chemicals, forest products, glass, metal casting, mining, petroleum, steel, cement, textiles, and other sectors[42] and sourcebooks, tip sheets, technical fact sheets and handbooks, and market assessments for steam, process heating, compressed air, and motors, pumps, and fans.[43]

Case studies providing information on commercial energy-saving technologies for a number of industrial sectors are also provided by the Centre for Analysis and Dissemination of Demonstrated Energy Technologies (CADDET).[44]

Reports or guidebooks help promote energy efficiency, advise companies on new technologies, methods or management, and give overall sectoral information. Examples include Australia's Energy Efficiency Best Practice Guides,[45,46,47] the Netherlands' descriptions of energy efficiency projects undertaken by LTA members,[48] Norway's Industrial Energy Efficiency Network sector reports,[49] and the UK Carbon Trust technology guides.[50] The Canadian Industry Program for Energy Conservation's sector-wide energy efficiency guides provide information on energy efficiency measures for

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[40] Galitsky, C., Price, L., and Worrell, E., 2004. *Energy Efficiency Programs and Policies in the Industrial Sector in Industrialized Countries*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-54068).

[41] http://www1.eere.energy.gov/industry/bestpractices/software.html

[42] http://www1.eere.energy.gov/industry/bestpractices/case_studies.html

[43] http://www1.eere.energy.gov/industry/bestpractices/technical.html

[44] http://www.caddet.org/index.php

[45] Industry Tourism Resources, 2003. *A Guide to Energy Efficiency Innovation in Australian Wineries: Energy Efficiency Best Practice.* Canberra: ITR.

http://www.industry.gov.au/assets/documents/itrinternet/WineGuide20040206170704.pdf

[46] Industry Tourism Resources, 2000. *Energy Efficiency Best Practice in the Australian Aluminium Industry: A Summary Report.* Canberra: ITR.

http://www.industry.gov.au/assets/documents/itrinternet/aluminiumsummaryreport20040206151753.pdf

[47] Industry Tourism Resources, 2000. *Energy Efficiency Opportunities in the Bread Baking Industry: Summary Report.* Canberra: ITR.

http://www.industry.gov.au/assets/documents/itrinternet/breadsummaryreport20040206153410.pdf

[48] http://www.senternovem.nl/LTA/projects/energy_efficiency/index.asp

[49] NVE, 1998. *Norwegian Industrial Energy Efficiency Network 1998*. Kjeller, Norway: NVE. http://ies.lbl.gov/iespubs/norwegian1998.pdf

[50] http://www.carbontrust.co.uk/energy/takingaction/publications.htm

aluminium, automotive, brewery, cement, dairy, foundry, lime, pulp/paper, rubber, and solid wood industries.[51] The U.S. ENERGY STAR for Industry Energy Guides [52] include both process-specific and utility energy efficiency measures for breweries,[53] cement,[54] corn refining,[55] fruit and vegetable processing,[56] glass,[57] motor vehicle assembly,[58] petroleum refining,[59] and pharmaceuticals.[60] The U.S. DOE has also published a sector-specific study for the cement industry.[61]

As part of the Dutch Long-term Agreements 2 (LTA2), SenterNovem and representatives of the sector develop and maintain a "measurement list" of possible efficiency improvements that consists of a detailed description of the measure, investment costs, energy savings, returns on investment and if financial support is available for the measure.[62]

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[51] http://oee.nrcan.gc.ca/industrial/technical-info/benchmarking/benchmarking_guides.cfm?attr=24#c

[52] http://www.energystar.gov/industry

[53] Galitsky, C., Worrell, E., Martin, N., and Lehman, B., 2003. Energy Efficiency Improvement and Cost Saving Opportunities for Breweries. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-50934) http://www.energystar.gov/ia/business/industry/LBNL-50934.pdf.

[54] Worrell, E. and Galitsky, C., 2004. *Energy Efficiency Improvement Opportunities for Cement Making: An ENERGY STAR Guide for Energy and Plant Managers*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-54036) http://www.energystar.gov/ia/business/industry/LBNL-54036.pdf.

[55] Galitsky, C., Worrell, E., and Ruth, M., 2003. *Energy Efficiency Improvement and Cost Saving Opportunities for the Corn Wet Milling Industry: A Guide for Energy and Plant Managers*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-52307)

http://www.energystar.gov/ia/business/industry/LBNL-52307.pdf

[56] Masanet, E., Worrell, E., Graus, W., and Galitsky, C., 2007. *Energy Efficiency Improvement and Cost Saving Opportunities for the Fruit and Vegetable Processing Industry: An ENERGY STAR Guide for Energy and Plant Managers.* Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-59289) http://ies.lbl.gov/iespubs/LBNL-59289.pdf

[57] Worrell, E., Galitsky, C., Masanet, E., and Graus, W., 2007. *Energy Efficiency Improvement and Cost Saving Opportunities for the Glass Industry: An ENERGY STAR Guide for Energy and Plant Managers.* Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-57335) http://ies.lbl.gov/iespubs/LBNL-57335.pdf

[58] Galitsky, C. and Worrell, E., 2003. *Energy Efficiency Improvement and Cost Saving Opportunities for the Vehicle Assembly Industry: An ENERGY STAR Guide for Energy and Plant Managers.* Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-50939)

http://www.energystar.gov/ia/business/industry/LBNL-50939.pdf

[59] Worrell, E. and Galitsky, C., 2005. *Energy Efficiency Improvement and Cost Saving Opportunities for Petroleum Refineries: An ENERGY STAR Guide for Energy and Plant Managers.* Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-56183)
http://www.energystar.gov/ia/business/industry/ES_Petroleum_Energy_Guide.pdf

[60] Galitsky, C., Chang, S., Worrell, E., and Masanet, E., 2005. *Energy Efficiency Improvement and Cost Saving Opportunities for the Pharmacuetical Industry: An ENERGY STAR Guide for Energy and Plant Managers.* Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-57260)
http://www.energystar.gov/ia/business/industry/LBNL-57260.pdf

[61] Choate, W.T., 2003. *Energy and Emission Reduction Opportunities for the Cement Industry*. Washington, DC: US Department of Energy, Industrial Technologies Program. http://www1.eere.energy.gov/industry/imf/pdfs/eeroci_dec03a.pdf

[62] SenterNovem presents lists with energy efficiency improvements for more than 20 sectors on their website: http://www.senternovem.nl/mja/tools/maatregellijsten/index.asp. To determine the return on

5. Benchmarking

Benchmarking provides a means to compare the energy use within one company or plant to that of other similar facilities producing similar products or to national or international best practice energy use levels. Benchmarking can compare plants, processes or systems.

The European Commission's project on *Energy Benchmarking at the Company Level Within Industry Voluntary Agreements* developed an automated computer system to allow companies to make a comparison with "the best of a branch" regarding the energy efficiency.[63] The project focused on three industrial sectors: bakeries,[64] breweries,[65] and dairies.[66] Individual plants in each sector were benchmarked in terms of production, revenue, specific energy consumption (energy use per physical unit of production), and a number of other indicators.

Canada's Office of Energy Efficiency (OEE) provides guidelines for both *energy performance benchmarking* in which a company compares its physical energy intensity to the average for its sector and *best practices benchmarking* in which a company compares itself to "best in class".[67] OEE has developed an energy calculator to assist companies in determining their facility's energy use by fuel type.[68] Once the energy intensity is calculated, the facility can be compared to the benchmarks for energy efficiency of facilities in the cement, fish and lobster processing, fluid milk, mining (open-pit and underground bulk), petroleum refining, potash, and pulp/paper sectors that OEE has publised.[69]

In the 1990s, Norway's Industrial Energy Efficiency Network (IEEN) developed an extensive benchmarking program. IEEN provided technical and financial support for companies to undertake energy management activities and assess their energy–efficiency potential through benchmarking. IEEN developed a web-based benchmarking system that allowed members to extract information about their own energy performance in relation to other plants within the same industrial sector. Every year industry network members provided data via the internet. Participating industries included: aluminium,

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investment (ROI), SenterNovem developed a tool to determine ROIs of measures. This Excel tool can be downloaded from: http://www.senternovem.nl/mmfiles/tvt_ncw_tcm24-111964.xls (in Dutch).

[63] http://www.energyagency.at/projekte/ideen2.htm#aea-publ

[64] EVA, 2001. *Energybenchmarking at the Company Level: Company Report Bakery*. http://www.energyagency.at/publ/pdf/ideen2_bakery_en.pdf

[65] EVA, 2001. *Energybenchmarking at the Company Level: Company Report Brewery.* http://www.energyagency.at/publ/pdf/ideen2_brewery_en.pdf

[66] [66] EVA, 2001. *Energybenchmarking at the Company Level: Company Report Dairy. http://www.energyagency.at/publ/pdf/ideen2_diary_en.pdf*

[67] http://oee.nrcan.gc.ca/industrial/technical-info/benchmarking/how-to-benchmark.cfm?attr=24

[68] http://oee.nrcan.gc.ca/industrial/technical-info/tools/energy-use-calculator.cfm?attr=24

[69] http://oee.nrcan.gc.ca/industrial/technical-info/benchmarking/benchmarking_guides.cfm?attr=24

bakeries, breweries, fishing, meat, dairy, grain-drying, fish meal, foundry, pulp and paper, timber and sawmill, and laundries and dry cleaners.[70]

In The Netherlands, benchmarks are a key element of the Benchmarking Covenants in which participating industrial companies agree to become one of the world's most efficient regions (regions defined as geographic areas with a production capacity similar to the Netherlands) or to be among the top 10% of the most energy-efficient plants in the world. The benchmarks are established as follows:

1) Most Efficient Region. In order to be compared to similar plants in one of the world's most efficient regions, regions outside of the Netherlands that are comparable with the Netherlands in terms of size and number of processing plants and which meet the best international standards are identified. The average energy efficiency of similar processing plants in these regions are then determined. The benchmark is the average energy efficiency in the region with the best average.

2) Top 10%. In order to be considered among the top 10% of the most energy-efficient plants in the world, the energy efficiency of comparable processing plants outside the Netherlands must be determined. These are ranked according to energy efficiency levels. The benchmark is the energy intensity of the best 10% of these processing plants.

If it is not possible to conduct either of the two studies outlined above, then the energy efficiency of the best processing plant outside of the Netherlands will be determined and the benchmark will be set at 10% below the energy efficiency of this facility.

Companies can provide information supporting the use of a different percentage given their specific situation. The Benchmarking Commission will determine whether sufficient support has been provided for the claim, after receiving recommendations from the independent authority. When defining the benchmarks, account will also be taken of the anticipated efficiency improvements up to 2012. Moreover, the world leader must be redefined every four years. It will not be possible to do this in every case. For example, if a unique process is involved or if the foreign plants do not want to take part in the benchmark, then a best practice-approach will be used to define the world leader.

The U.S. ENERGY STAR for Industry program provides a means for measuring how efficiently a manufacturing plant uses energy compared to others in its industry in the U.S. using a tool called the energy performance indicator (EPI). The EPI is an industry-specific tool that ranks or scores a plant based on its energy use and accounts for differences between the plants within an industry by normalizing for activities or factors that influence energy use. The model enables plant and corporate energy managers to input key operating conditions for a plant and receive a percentile score of their energy performance or efficiency. Common inputs include actual energy use in all forms and actual production at that site. When possible, as is permitted by the data, the EPI will relate energy to plant output as measured by units of product. The score, on a scale of 1

[70] Institute for Energy Technology, 1998. *Norwegian Industrial Energy Efficiency Network 1998*. Kjeller, Norway: Institute for Energy Technology. http://ies.lbl.gov/iespubs/norwegian1998.pdf

to 100, represents the plant's position relative to all others of similar operation within the industry in the U.S. The EPI helps companies assess the current efficiency of their plants, prioritize where they will allocate limited resources for improvement, and track progress. EPI benchmarking tools are currently available for the cement, corn refining, and motor vehicle manufacturing sectors.[71]

Lawrence Berkeley National Laboratory in the U.S. has developed an Excel-based spreadsheet tool called BEST: Benchmarking and Energy Saving Tool for industry to benchmark a plant's energy intensity to best practice and to identify energy-efficiency options that can be implemented by the plant. Some BEST tools also include as assessment of water consumption and identification of water saving technologies and practices. Best practice in BEST is defined as a plant that uses all cost-effective, commercially-available best practice technologies for each major manufacturing process (cost effective is generally defined as those technologies with a payback period of three years or less). Users input readily-available information on production and energy consumption by fuel and electricity at their plant and BEST compares the plant performance to best-practice, at both the process and total plant levels. Once the plant has been benchmarked, energy-efficiency technologies and measures contained in the spreadsheet tool that could be implemented in the plant can be chosen by the user. The tool provides a description of each technology or measure and quantifies the energy savings and simple payback period if implemented in the plant. After the energy-efficiency measures that could be implemented are chosen,, BEST calculates a revised benchmark value, showing how much closer the plant will be to best practice once the measures are implemented. BEST has currently been developed for the California wine industry[72] and development of BEST for the Chinese cement and iron/steel industry is underway.

[71] http://www.energystar.gov/industry

[72] http://best-winery.lbl.gov/

6. Energy Management[73]

Changing how energy is managed by implementing an organization-wide energy management program is one of the most successful and cost-effective ways to bring about energy efficiency improvements. Crosscutting equipment and technologies common to most plants and manufacturing industries, such as compressed air and motors, provide well-documented opportunities for improvement. Equally important, the production process can be fine-tuned to produce even greater savings. An energy management program provides guidance for managing energy throughout an organization. In companies without a clear program in place, opportunities for improvement may be known but may not be promoted or implemented because of organizational barriers. These barriers may include a lack of communication among plants, a poor understanding of how to create support for an energy efficiency project, limited finances, poor accountability for measures or perceived change from the status quo.

A successful program in energy management begins with a strong commitment to continuous improvement of energy efficiency. This involves assigning oversight and management duties to an energy director, establishing an energy policy, and creating a cross-functional energy team. Steps and procedures are then put in place to assess performance, through regular reviews of energy data, technical assessments and benchmarking. From this assessment, an organization is able to develop a baseline of energy use and set goals for improvement. Performance goals help to shape the development and implementation of an action plan. An important aspect for ensuring the successes of the action plan is involving personnel throughout the organization. Personnel at all levels should be aware of energy use and goals for efficiency. Staff should be trained in both skills and general approaches to energy efficiency in day-to-day practices. In addition, performance results should be regularly evaluated and communicated to all personnel, recognizing high achievement. The use of energy monitoring and process control systems can play an important role in energy management and in reducing energy use. These may include sub-metering, monitoring, and control systems. They can reduce the time required to perform complex tasks, often improve product and data quality and consistency, and optimize process operations. A corporate energy management system can be expanded to provide a framework to standardize, measure, and recognize industrial system optimization efforts.[74]

Energy management standards or other forms of guidance have been developed for use in a number of countries, often in conjunction with voluntary agreements. Such energy management standards are based on the "plan-do-check-act" approach as illustrated in Figure 3.

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[73] Some information in this section has been excerpted from: McKane, A., 2007. "Industrial Energy Management: Issues Paper" Prepared for Expert Group Meeting: Using Energy Management Standards to stimulate persistent application of Energy Efficiency in Industry, Vienna, Austria, March 21-22, 2007 and : McKane, Aimee, 2007, *Industrial Energy Management: Issues Paper* and McKane, A., R. Williams, W. Perry, and T. Li. 2007. *Setting the Standard for Industrial Energy Efficiency.*

[74] Worrell, E. and Galitsky, C., 2004. *Energy Efficiency Improvement and Cost Saving Opportunities for Cement Making: An ENERGY STAR® Guide for Energy and Plant Managers*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-54036).

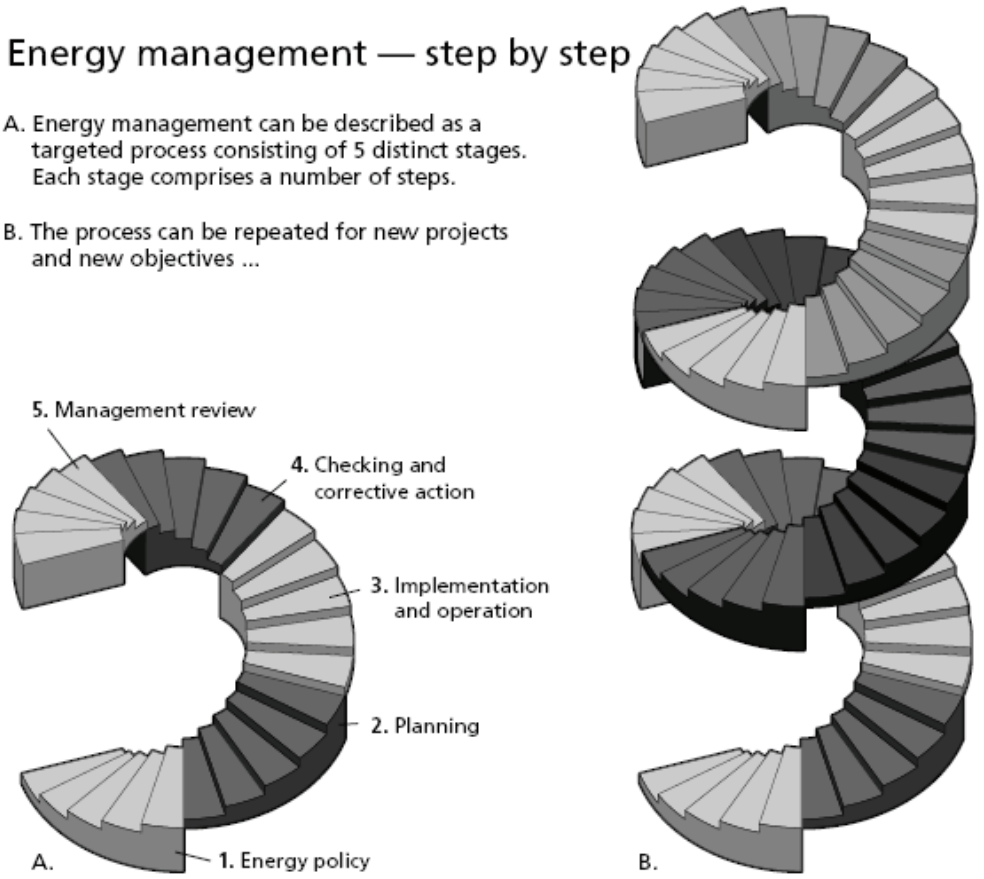

Figure 3. Energy Management Diagram

Source: Danish DS 2403:2001, Energy Management-Specification.

Typical features of an energy management standard include:

- a strategic plan that requires measurement, management, and documentation for continuous improvement for energy efficiency;
- a cross-divisional management team led by an energy coordinator who reports directly to management and is responsible for overseeing the implementation of the strategic plan;
- policies and procedures to address all aspects of energy purchase, use, and disposal;
- projects to demonstrate continuous improvement in energy efficiency;
- creation of an Energy Manual, a living document that evolves over time as additional energy saving projects and policies are undertaken and documented;
- identification of key performance indicators, unique to the company, that are tracked to measure progress; and
- periodic reporting of progress to management based on these measurements.

The European Union's Environmental Management and Audit Scheme (EMAS) outlines requirements for the voluntary participation of industrial operations towards an environmental management and environmental audit scheme in the EU. A collaborative

project with partners from Finland, Sweden, Denmark, England and Austria aimed to increase the focus on energy management related to EMAS registration. As a result, an EMAS-adapted guidebook on energy management, targeting companies working for EMAS registration and including specific cases from EMAS companies where energy has been explicitly addressed, was developed.[75]

Table 2 compares the elements of the energy management standards in five countries (Denmark, Ireland, Netherlands, Sweden, U.S.), along with the standard under development in China.[76] For all five countries with existing energy management standards (or specifications), the standard has been developed to be entirely compatible with the ISO quality management program (ISO 9001:2000) and environmental management program (ISO 14001). In the case of Denmark, Ireland, and Sweden, the assumption is that industrial facilities participating in ISO 14001 will integrate the requirements of the standard into their existing management documentation and procedures.

Denmark has had a CO_2 tax in place since 1992 on all energy sources in Denmark. Because of concerns that the tax would make energy-intensive Danish industries non-competitive, the government introduced voluntary agreements that offered a CO_2- tax rebate for adopting energy management practices and undertaking energy efficiency measures. To be eligible, companies had to be listed by the Danish Energy Authority as energy-intensive and the company's energy-tax load had to exceed 4 percent of the company's value added in the year prior to signing the agreement. These agreements have become an important driver in encouraging use of the energy management standard in Denmark. Energy-intensive companies that enter into agreements for tax benefits must implement all energy-efficiency measures related to heavy processes with a payback period of four years or less; for less energy intensive companies signing agreements, the implementation requirement expends to measures with payback periods of six years or less. The energy management standard has to be verified and certified annually in accordance with the requirements of the Danish Standard on Energy Management, DS 2403.

The Danish Energy Authority has developed the concept of energy management in close cooperation with industrial organisations.[77] The purpose of the energy management standard is to ensure that energy savings achieved in daily operations can be maintained, that intervention takes place in cases of inefficient operations and that new

[75] Oestfold Research Foundation and the Institute for Energy Technology, 1999. *EMAS Guidebook: Integrating Energy and Environmental Management.* http://www.energyagency.at/publ/pdf/emas-handbok.pdf

[76] The China Standard Certification Center (CSC) has been authorized by the Chinese government to develop a series of national energy management standards. Three standards are planned for release by March 2008: Management System for Energy: Requirements, Management System for Energy: Guidelines for Performance, and Management System for Energy: Guidelines for Auditing. The draft Requirements standard has much in common with the other energy management standards in use elsewhere around the world.

[77] Danish Standards Committee S 365 Energy Management, 2001. *Energy Management – Guidance on Energy Management* (DS/INF 136 E). http://ies.lbl.gov/iespubs/Danish%20EM%20Standard.pdf

possibilities for energy efficiency are continuously evaluated. In addition, the energy management standard contains guidelines on energy efficient procurement.

Sustainable Energy Ireland (SEI) implements an industrial energy agreement program based on the new Irish Energy Management Standard, IS 393.[78,79] The SEI Energy Agreements focus on large, energy-intensive industrial enterprises, with an annual energy costs of €2 million or more.[80] Participating firms are required to become certified to the Energy Management Standard which established structures and processes designed to bring significant savings in energy, associated costs and greenhouse gas emissions. The Energy Management Standard requires that senior management be directly involved in establishing and supporting energy-saving and emissions reduction policies. An energy review to gain an understanding of baseline energy use in the organization is used to prioritize efforts to reduce energy use. The Energy Management Standard is similar to and compatible with the Environmental Management System Standard ISO 14001.

In The Netherlands, guidance for establishing an Energy Management System based on the ISO 14001 standard for environmental management systems has been developed in support of the Long-Term Agreements.[81] Companies that joined the LTA2 have an obligation to implement an energy management system within two years. The requirements are explained and outlined in *Structural Attention for Energy Efficiency by Energy Management*,[82] *The Energy Management System Specification with Guidance for Use*[83] and the *Energy Management Checklist* which provides a means to verify which requirements have been fulfilled and which require improvement.[84]

Sweden has had a voluntary agreement program since 1994, but only added an energy management standard as a program requirement in 2003. In 2005, after Sweden imposed a tax on industrial process-related electricity, the Programme for Improving Energy Efficiency in Energy-Intensive Industries (PFE) was launched.[85] Managed by the

[78] http://www.sei.ie/index.asp?locID=628&docID=-1

[79] Sustainable Energy Ireland, 2006. *Energy Management Systems. I.S. 393:2005 Technical Guideline*. http://ies.lbl.gov/iespubs/IS393_Technical_guideline.pdf

[80] Sustainable Energy Ireland, 2006. *Sustainable Energy Ireland's Energy Agreements Programme*. http://ies.lbl.gov/iespubs/SEI.Agreement.description.pdf

[81] http://www.senternovem.nl/Energiezorg/english/index.asp

[82] SenterNoven, 2004. *Structural Attention for Energy Efficiency by Energy Management.* Sittard and Utrecth, The Netherlands: SenterNovem. http://www.senternovem.nl/mmfiles/3MJAF04.17%20-%20Structural%20attention%20for%20energy%20efficiency%20by%20energy%20management%20-%20June%202004_tcm24-122943.pdf

[83] SenterNoven, 2004. *The Energy Management System Specification with Guidance for Use.* Sittard and Utrecth, The Netherlands: SenterNovem. http://www.senternovem.nl/mmfiles/3MJAF04.16%20-%20Energy%20Management%20System%20Specification%20with%20Guidance%20for%20Use%20-%20June%202004_tcm24-122944.pdf

[84] SenterNovem, 2004. *Energy Management Checklist*. Sittard and Utrecht, The Netherlands: SenterNovem. http://www.senternovem.nl/mmfiles/3MJAF04%2E15%20-%20Energy%20Management%20Checklist%20-%20June%202004_tcm24-122945.pdf

[85]http://www.energimyndigheten.se/WEB/STEMEx01Eng.nsf/F_PreGen01?ReadForm&MenuSelect=F78F2B2CB1DE4525C12570FB00428BD8

Swedish Energy Agency, the PFE offers reduced taxation for companies that introduce and obtain certification for a standardized energy management system and undertake electrical energy efficiency improvements. The program requires the following:[86]

1. Energy audit and analysis. The company must carry out a audit of actual energy use. It will then analyze the results of the audit and identify measures to improve energy efficiency. This is a requirement of the energy management standard, and must, therefore, be verified by the certification body. (More on energy audits is contained in Section 7).

2. Energy management systems. A participating company must introduce a standardized energy management system during the first two years, and the system must then be certified by an accredited certification body. The company will then apply the energy management standard throughout the program period. The certification body will verify that the participating company meets the requirements of the energy management standard and then issue confirmation that the company meets the requirements. To verify that the company is working in accordance with the standard, periodical audits will be carried out during the program period. If, during a periodical audit, it emerges that the company is not fulfilling the requirements for retaining certification, and, therefore, does not meet the requirements for continued participation in PFE, the company must notify the Swedish Energy Agency.

3. List of measures to improve electricity efficiency. The energy audit and the subsequent analysis will be used to draw up a list of identified measures to improve energy efficiency which the certification body will review. The Swedish Energy Agency will also require this for information. From this list, measures to improve electricity efficiency will be selected and reported in more detail to the Swedish Energy Agency. This list of measures need not be verified by the certification body.

4. Procedures for purchasing high-consumption electrical equipment. When purchasing high-consumption electrical equipment which uses more than 30 MWh per year, participating companies must select the equipment which is most energy-efficient on the basis of energy classification or estimated lifecycle cost. This is conditional on the estimated pay-back time of the additional cost of the energy-efficient equipment being less than three years, compared with equipment that is identical in other respects. Participating companies must develop and implement purchasing procedures which describe the methods used by the company to ensure that the purchasing requirement is satisfied.

5. Procedures for project planning. In project planning, alterations and renovations of their plant, participating companies must indicate a number of solutions and assess how they can interact with their existing plant to improve energy efficiency and assess lifecycle costs. This will ensure that the alternative with the lowest energy consumption will be selected when the operation is expanded. The companies must, therefore, develop and implement procedures to ensure that a number of alternative solutions are compared, and that the least energy-consuming alternative overall is selected. The procedures must include investigating how the project can interact with other parts of the operation, i.e. systems thinking must be part of the approach.

[86] http://www.energimyndigheten.se/WEB/STEMEx01Eng.nsf/F_PreGen01?ReadForm&MenuSelect=837F9EDA126F675DC12570FB004FB7D7

By the end of five years, the company must implement the listed measures, demonstrate continued application of the energy management standard and procurement procedures, and assess the effects of project planning procedures. As of January, 2007, 126 companies had signed up to participate in PFE, representing approximately 50% of all industrial electricity use. To join, companies must be in certain eligible classes, use electricity in their manufacturing process, have energy costs of at least 3% of production value or pay at least 0.5% of value-added in energy-related taxes, and have the economic means to carry out the program. To assist companies in compliance, the government has published handbooks on energy management, energy audits and analysis, routines for purchasing and planning, and a template for calculating life cycle cost in accordance with program requirements.

In the U.S., engineers at the Energy and Environmental Management Center of the Georgia Institute of Technology (Georgia Tech) developed a management system for energy (MSE) that was adopted by the American National Standards Institute (ANSI) in 2000.[87] ANSI/MSE 2000:2005 is not a prescriptive standard, but rather provides a framework for a management system that lowers energy costs, reduces environmental impacts, aligns actions with organizational strategies and goals, sustains productivity and savings improvements, and encourages continual improvement.[88]

The U.S Environmental Protection Agency's Energy Star for Industry program provides Guidelines for Energy Management with detailed information on how to undertake the following steps: 1) Make Commitment, 2) Assess Performance, 3) Set Goals, 4) Create Action Plan, 5) Implement Action Plan, 6) Evaluate Progress, and 7) Recognize Achievements.[89] EPA has also developed an Energy Program Assessment Matrix to help organizations and energy managers compare their energy management practices to those outlined in the Guidelines and a Facility Energy Assessment Matrix to help energy managers evaluate management at their facilities.[90]

[87] http://innovate.gatech.edu/Default.aspx?tabid=2005, to purchase a copy of the standard: http://webstore.ansi.org/RecordDetail.aspx?sku=ANSI/MSE%202000:2005

[88] http://innovate.gatech.edu/Default.aspx?tabid=2005

[89] http://www.energystar.gov/index.cfm?c=guidelines.guidelines_index

[90] http://www.energystar.gov/index.cfm?c=guidelines.guidelines_index

Table 2. Energy Management Standards.

Participating Countries	Management Commitment Required	Develop energy management plan	Establish energy use baseline	Identify Energy Coordinator	Establish Cross- Divisional Implementation Team	Emphasis on Continuous Improvement	Document Energy Savings	Establish Performance Indicators & Energy Saving Targets	Document & Train Employees on Procedural/ Operational Changes	Specified Interval for Re-evaluating Performance Targets	Reporting to Public Entity Required	Energy Savings Validated or Certified	Year Published	Approx Market Penetration by Industrial Energy Use
Existing														
Denmark	yes	yes	yes	yes	yes	yes	yes	yes	yes	suggests annual	yes	optional[1]	2001	60%[2]
Ireland	yes	yes	yes	yes	yes	yes	yes	yes	yes	industry sets own	yes	optional[1]	2005	25%
Netherlands[3]	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	optional[1]	2000	20-90%[4]
Sweden	yes	yes	yes	yes	unclear	yes	yes	yes	yes	yes[1]	yes	optional[1]	2003	50%elect
United States	yes	yes	yes	yes	yes	yes	yes	yes	yes	industry sets own	no	no	2000	<5%[5]
Under Development														
China	yes	yes	yes	yes	yes	yes	yes	yes	yes	industry sets own	not avail	not avail		

1 Certification is required for companies participating in voluntary agreements (also specified interval in Sweden). In Denmark, Netherlands & Sweden linked to tax relief eligibility.

2 As of 2002, latest date for which data is available

3 Netherlands has an Energy Management System, not a standard, per se, developed in 1998 and linked to Long Term Agreements in 2000.

4 800 companies representing 20% of energy use have LTAs and must use the Energy Management System. The 150 most energy intensive companies, representing 70% of the energy use, have a separate, more stringent, bench marking covenant and are typically ISO 14000 certified, but are not required to use the EM System.

5 To date, the US government has encouraged energy management practices, but not use of the standard, therefore market penetration has been very limited. Program policies new in 2007 are designed to address this.

7. Energy-Efficiency Audits

Auditing enterprises involves collecting data on all of the major energy-consuming processes and equipment in a plant as well as documenting specific technologies used in the production process and identifying opportunities for energy efficiency improvement throughout the plant, typically presented in a written report. Tools, informational materials, and other energy efficiency products are often furnished during the audit. Some audit programs, like the U.S. Department of Energy's Energy Savings Assessments program, provide a directory or network of accredited auditors.[91]

In the mid-1990s, the International Energy Agency convened an expert group on industrial energy audits and a project on Energy Audit Management Procedures within the European Union's Specific Actions for Vigorous Energy Efficiency (SAVE) Programme was launched in March 1998 to evaluate energy auditing practices in the European Union. The effort interviewed energy audit experts, developed country reports, identified state-of-the-art procedures and success stories, and harmonized definitions of energy auditing. The project's final report, *The Guidebook for Energy Audits, Programme Schemes and Administrative Procedures*, explains that the core elements of an energy audit are evaluating the present energy consumption, identifying energy saving possibilities, and reporting.[92]

The SAVE project report explains that there are many types of energy audits that vary in scope and complexity. Scan-type audits identify the major energy-consuming areas of a facility and point out energy-saving measures that can be applied. An example of a scan-type audit is a walk-through audit for facilities with simple energy-consuming systems, typically small and medium sized industrial facilities. Another scan-type audit is a preliminary energy audit which is typically performed by a team of energy experts and provides a breakdown of the facility's current energy consumption and identifies probably energy-saving measures. More in-depth analyzing audits include system-specific audits that identify the energy saving potential of one specific system, device, or process; selective audits in which the auditor focuses on specific systems seeking those with the major energy-saving opportunities; targeted audits in which certain low energy-consuming areas are excluded from the audit; and comprehensive energy audits that cover all of the facility's energy consumption, including mechanical and electrical systems, process supply systems, and all energy using processes.[93]

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[91] http://www1.eere.energy.gov/industry/bestpractices/qualified_specialists.html

[92] MOTIVA (Energy Information Centre for Energy Efficiency and Renewable Energy Sources, Finland), IFE (Institute for Energy Efficiency, Norway) and CRES (Center for Renewable Energy Sources, Greece), 2000. *The Guidebook for Energy Audits, Programme Schemes and Administrative Procedures, http://www.motiva.fi/attachment/f16d4d543f99d7a59f54560a69063a0e/435cc93f15c4dd7272d126f40f2b006e/Audit-final-report.pdf*

[93] MOTIVA (Energy Information Centre for Energy Efficiency and Renewable Energy Sources, Finland), IFE (Institute for Energy Efficiency, Norway) and CRES (Center for Renewable Energy Sources, Greece), 2000. *The Guidebook for Energy Audits, Programme Schemes and Administrative Procedures, http://www.motiva.fi/attachment/f16d4d543f99d7a59f54560a69063a0e/435cc93f15c4dd7272d126f40f2b006e/Audit-final-report.pdf*

The SAVE project produced a number of additional information sources, including a *Guidebook for Energy Audit Program Developers* that provides information on training, authorization, quality control, monitoring, evaluation, energy audit models, and auditor tools based on auditing programs in 16 European countries,[94] a *Topic Report on Auditors' Tools* that discusses a variety of auditing tools used within European auditing programs,[95] and a *Topic Report: Training, Authorisation, and Quality Control that discusses* energy auditor training, authorization of energy auditors, and quality control of energy audits.[96]

Individual plant audits conducted as part of the Dutch Long-Term Agreements included a description of the sector, an assessment of the plant's energy consumption in the base year, a survey of opportunities for energy-efficiency improvement, and a description of the monitoring and energy management techniques used.[97] Identified energy-efficiency measures were grouped in five categories: good housekeeping/energy management, retrofit or strategic investments, energy-efficiency investments, cogeneration, and other measures (e.g. changes in feedstock). The individual enterprise audits were done by the company itself and/or by independent consultants. The results of the audits were reported to an independent government agency, and provided the basis for final discussions and negotiations between the industries and the government to establish the final target for the sector. The assessments were further used as a basis for the company Energy Savings Plan which included an assessment of energy consumption in the base year, a survey of opportunities for energy-efficiency improvement, monitoring and energy management, research and development of new energy-efficient technologies, and demonstration projects of energy-saving measures.

As part of the Danish CO_2 Tax Rebate Scheme for Energy-Intensive Industries, energy audits of individual plants were conducted by independent, approved consultants. The energy audit was required to include the following: an energy balance for the plant with a detailed breakdown of energy consumption by processes, description of the energy-efficiency projects at the plant, including potential future projects, recommendations for energy management, and recommendations for energy conservation investments.[98] The purpose of the energy audit was to identify all profitable energy measures. In heavy processes (like greenhouse heating and production of food, sugar, paper, cement and glass) profitable refers to energy efficiency with a payback period of less than four years. In light processes (energy tax of the company exceeds 4% of the

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[94] Väisänen, H., et al., 2003. AUDIT II - *Guidebook for Energy Audit Programme Developers*. http://www.energyagency.at/publ/pdf/audit_guidebook.pdf

[95] Ademe, 2002. *Topic Report on Auditors' Tools*. http://www.energyagency.at/publ/pdf/audit_tools.pdf

[96] Väisänen, H. and Reinikainen, E., 2002. *Topic Report: Training, Authorisation, and Quality Control.* http://www.energyagency.at/publ/pdf/audit_train.pdf

[97] Nuijen, W., 2002. "Energy Auditing, Assessments, and Energy Plans in The Netherlands," Presentation at the *Workshop on Voluntary Agreements for China's Industrial Sector: Integrating International Experiences into Designing a Pilot Program*, February 25-27, 2002, http://ies.lbl.gov/iespubs/energyaudits.pdf

[98] Ezban, R., Tang, E., and Togeby, M., 1994. "The Danish CO_2-Tax Scheme," in International Energy Agency, *Conference Proceedings – Industrial Energy Efficiency: Policies and Programs*, Washington DC, 26-27 May, 1994.

company's value added) profitable is defined by a payback period less than six years. The energy audits were carried out by either by consultants or company staff. The audits were verified by an independent certified verification agency. Sector-wide reports were also prepared. These reports provide a sector-wide analysis of energy consumption and production processes and identify the general potential for energy-efficiency improvement in the companies within the sector.[99, 100]

The Swedish National Energy Administration (STEM), as a part of the EKO Energi Agreements, provides a comprehensive inventory and analysis of energy use in a company's production and premises, and includes a list of possible actions to be taken. STEM also provides a comprehensive material flow analysis as well as an introductory comparison of the company's environmental awareness and management and guidelines based on EMAS or ISO 14001 standards.[101]

The U.S. Department of Energy (DOE)'s Industrial Assessment Centers, located at 26 universities throughout the U.S., perform in-depth assessments of industrial facilities including a detailed evaluation of potential savings from energy efficiency improvements, waste minimization and pollution prevention, and productivity improvements. The assessment team surveys the plant and takes engineering measurements that are the basis for the detailed analysis with related cost, performance, and payback time estimates. These results are then presented to the plant in a confidential report with findings and recommendations.[102] In 2001, the IACs performed 590 facility assessments that identified 3,350 energy efficiency recommendations with an average simple payback time of 0.9 years. Of those, facilities implemented 1,550 (46%) of the recommendations and the implemented recommendations had an average simple payback time of 0.5 years.[103]

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[99] Togeby, M., Bjorner, T.B., and Johannsen, K., 1998. "Evaluation of the Danish CO_2 Taxes and Agreements," in Martin et al., (eds.) *Industrial Energy Efficiency Policies: Understanding Success and Failure: Proceedings of a Workshop Organized by the International Network for Energy Demand Analysis in the Industrial Sector*. Utrecht, The Netherlands, June 11-12, 1998, LBNL-42368, http://ies.lbl.gov/iespubs/42368.pdf.

[100] The obligation to do an energy audit before signing a voluntary agreement was removed in the revised scheme (2002). Instead of the energy audit, the participating companies must now do an energy flow screening covering the most energy-intensive parts of their production process. The purpose of the energy flow screening is not to identify profitable energy savings projects, but to identify areas or parts of the production process that are relevant to study further in special investigation (Ericsson, K., 2006 *Evaluation of the Danish Voluntary Agreements on Energy Efficiency in Trade and Industry*, http://www.aid-ee.org/documents/011Danishvoluntaryagreements.PDF).

[101] Uggla, U. and Avasoo, D., 2001. "EKO-Energi – Successful Voluntary Agreements on Energy Efficiency and Environmental Control in Swedish Industry." *Proceedings of the 2001 ECEEE Summer Study*. European Council for an Energy-Efficient Economy.

[102] http://www.iac.rutgers.edu/database/about.php

[103] Muller, M.R., 2001. *Savings Generated by the Industrial Assessment Center Program: Fiscal Year 2001*. http://www.iac.rutgers.edu/database/technicaldocs/IAC_Annual_Reports/01an_rep.pdf

In 2006, the U.S. DOE's Industrial Technologies Program initiated the Save Energy Now program that provides trained energy experts to perform Energy Savings Assessments at the most energy-intensive manufacturing facilities in the U.S. The purpose of the assessments is to identify immediate opportunities to save energy and money, primarily by focusing energy intensive systems such as process heating, steam, compressed air, fans, and pumps.[104] In 2006, the Save Energy Now program completed 200 assessments at large manufacturing plants and found that the typical large plant can reduce its energy bill on average by over $2.5 million per plant, for a total of $500 million in identified energy cost savings and over 4 million metric tons of CO_2 emissions reductions. The assessments targeted the largest energy-consuming manufacturing plants, consuming 1 trillion Btu or more annually, and six industries (over 80% of the assessments were in these industries): chemical manufacturing, paper manufacturing, primary metals, food, non-metallic mineral products, and fabricated metal products. Six-month follow up surveys indicated that about 7% of the recommendations have been implemented, saving an estimated $30 million annually and more than 70% of the recommendations have been implemented, are in progress, or are planned for implementation.[105] Assessment reports, which include near-term, medium-term, and long-term opportunities for energy saving, are provided to the company and also posted on DOE's Energy Savings Now website.[106]

[104] http://www1.eere.energy.gov/industry/saveenergynow/assessments.html

[105] Wright, A., Martin, M., Gemmer, B., Scheihing, P., and Quinn, J., 2007. *Results from the U.S. DOE 2006 Save Energy Now Assessment Initiative: DOE's Partnership with U.S. Industry to Reduce Energy Consumption, Energy Costs, and Carbon Dioxide Emissions* (ORNL/TM-2007/138). Washington, DC: US Department of Energy, Industrial Technologies Program.
http://www.eere.energy.gov/industry/saveenergynow/partners/pdfs/sena_2006_report_final_09_17_07.pdf

[106] http://www.eere.energy.gov/industry/saveenergynow/partners/results.cfm

8. Energy Saving Action Plans

An energy action plan outlines an enterprise's plan for improving energy-efficiency during the period covered by energy efficiency targets. The energy action plan is primarily the guidance for the internal implementation of the activities that will be undertaken to reach the energy-saving target. It also serves as a reference to evaluate progress on an annual basis. The energy action plan should include a description of the enterprise with respect to energy, a description of the energy-efficiency measures considered, a description of the planned energy-efficiency measures, a timeframe for implementation of the energy-efficiency measures, and expected results in terms of energy efficiency. Once the energy action plan is drafted, it is typical for an independent third party to review the plan and make suggestions for adjustments, if needed. If conditions change at the enterprise or if planned energy-efficiency projects change, the energy action plan should be revised and submitted to the independent third party for additional review.

In the Long-Term Agreements in The Netherlands, energy assessments were used as a basis for the industry energy-saving action plans, called Long Term Plans, which included evaluation of energy consumption in the base year, a survey of opportunities for energy-efficiency improvement, company energy plans, monitoring and energy management in each company, research and development of new low-energy technologies, demonstration projects for energy savings measures, assistance to individual companies, and information dissemination.[107] The individual company plans provided the basis for the sector-wide plan. All companies reported the results of the energy monitoring, as well as the implemented projects, annually. Based on the performance, the Energy Savings Plan was adapted in order to achieve the agreed-upon target.

In the LTA2 program, companies are required to draft an Energy Conservation Plan (ECP) setting out their energy efficiency goals, the measures they intend to employ, and a schedule for reaching their goals every four years. The plan must be reviewed every four years when "world best practice" is redefined.[108] The ECP also outlines how the company or institution determines its energy efficiency index (EEI) and how this will be reported. The covenant contains criteria governing the rate of investment. Companies must begin by taking the most cost-effective measure, followed by measures that are less cost-effective. If after this they have not reached the world lead, they can also use flexible instruments such as trade in emission rights from 2008 onwards. With these measures, the company or institution also creates the basis for the development of the energy paragraph in their environmental license. SenterNovem, an agency of the Dutch Ministry of Economic Affairs, performs an assessment to determine whether the ECP meets the requirements of an LTA.[109,110]

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[107] Nuijen, W., 1998. "Long Term Agreements on Energy Efficiency in Industry," in Martin et al., (eds.) Industrial Energy Efficiency Policies: Understanding Success and Failure: Proceedings of a Workshop Organized by the International Network for Energy Demand Analysis in the Industrial Sector. Utrecht, The Netherlands, June 11-12, 1998 (LBNL-42368).

[108] http://www.benchmarking-energie.nl/standaard.php3?pagid=326

[109] http://www.senternovem.nl/LTA/energy_conservation_plan/index.asp

9. Financial Incentives

Tax and fiscal policies for encouraging investment in energy-efficient industrial equipment and processes operate either through increasing the costs associated with energy use to stimulate energy efficiency or by reducing the costs associated with energy efficiency investments. Various forms of these instruments have been tried in numerous countries over the past three decades. In addition, integrated policies that combine a variety of financial incentives in a national-level energy or GHG emissions mitigation program are also found in a number of countries. Such integrated policies are often national-level energy or GHG programs that combine a number of tax and fiscal policies along with other energy efficiency mechanisms such as voluntary agreements.[111]

Incentives for investing in energy-efficiency technologies and measures include targeted grants or subsidies, tax relief, and loans for investments in energy efficiency. Grants or subsidies are public funds given directly to the party implementing an energy efficiency project. Loans subsidized by public funding as well as loans that are offered at interest rates below market interest rates can be directed for investments in energy efficiency. Innovative loan mechanisms include equity participation through ESCOs, guarantee funds, revolving funds, and the use of venture capital. Tax relief for purchase of energy-efficient technologies can be granted through tax exemptions, tax reductions, and accelerated depreciation. A common approach is to provide a list of technologies for special tax treatment. Depending upon the specific program, this tax treatment could be: 1) *accelerated depreciation* where purchasers of qualifying equipment can depreciate the equipment cost more rapidly than standard equipment, 2) *tax reduction* where purchasers can deduct a percentage of the investment cost associated with the equipment from annual profits, or 3) *tax exemptions* where purchasers are exempt from paying customs taxes on imported energy-efficient equipment.[112]

9.1 Energy or CO_2 Taxes

Energy or energy-related carbon dioxide (CO_2) taxes have been used in a number of countries to provide an incentive to industry to improve the energy management at their facilities through both behavioral changes and investments in energy efficient equipment. Taxes on energy or energy-related CO_2 emissions were first adopted in a number of northern European countries in the early 1990s. Such taxes are now found in Austria, the Czech Republic, Denmark, Estonia, Finland, Germany, Italy, the Netherlands, Norway, Sweden, Switzerland, and the UK. In target-setting programs that involve the use of energy taxes, such as the Climate Change Agreements in the UK and the Danish energy efficiency agreements, rewards for meeting agreed-upon targets are provided in

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[110] SenterNovem, 2002. *Handbook Energy Conservation Plan (ECP).* http://www.senternovem.nl/mmfiles/Handbook%20ECP_tcm24-173539.doc

[111] Much of this section is based on information from Galitsky, C., L. Price, and E. Worrell., 2004. *Energy Efficiency Programs and Policies in the Industrial Sector in Industrialized Countries.* Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-54068) http://ies.lbl.gov/iespubs/54068.pdf.

[112] Price, L., Galitsky, C., Sinton, J., Worrell, E., Graus, W., 2005. *Tax and Fiscal Policies for Promotion of Industrial Energy Efficiency: A Survey of International Experience*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-58128) http://ies.lbl.gov/iespubs/58128.pdf.

the form of a reduction of the required energy tax.[113, 114] The French AERES agreements include a penalty fee imposed at the end of two evaluation periods if the targets are not met.[115]

In 1991, the Swedish Carbon Tax was introduced. Industries were only required to pay 50% of the tax to maintain competitiveness and certain high energy-using industries such as commercial horticulture, mining, manufacturing, and the pulp and paper industry were fully exempted from the tax. In 2004, an EU directive led to an increased electricity tax of €0.5/MWh which affected most Swedish industrial companies. As a result, the Programme for improving energy efficiency in energy-intensive industry (referred to as "PFE") was introduced. At the end of PFE's second year in 2006, 117 companies representing about one fifth of Sweden's total electricity consumption are participating in the program. Nearly all of the companies have now submitted their first reports on energy efficiency improvement activities undertaken, including energy audits and analysis of their energy use as well as introduction of certified energy management systems. In 2006, 98 companies submitted their two year report and outlined nearly 900 energy efficiency improvements that they plan to undertake by 2009. The improvements will cost the companies about €110 million and reduce electricity consumption by 1 TWh/year, saving the companies €55 million per year. In addition, the companies will receive €17 million tax reductions through their participation in this program (see section 9.4).[116, 117, 118]

9.2 Grants and Subsidies

Beginning in the 1970s, grants or subsidies for investments in energy efficiency were among the first policy measures to be implemented and remain the most widespread fiscal incentives used today. A recent survey found that 28 countries provide some sort of grant or subsidy for industrial energy efficiency projects.[119] Grants or subsidies are public funds given directly to the party implementing an energy efficiency project. Those providing the grants or subsidies, generally the public sector, do not seek a direct financial benefit in the form of return on investment. Due to problems with free-riders,

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[113] Department of Environment, Food, and Rural Affairs (DEFRA), 2004. *Climate Change Agreements: The Climate Change Levy*. http://www.defra.gov.uk/environment/ccl/intro.htm

[114] Togeby, M., K. Johannsen, C. Ingrslev, K. Thingvad, and J. Madsen, 1999. "Evaluations of the Danish Agreement System," *Proceedings of the 1999 American Council for an Energy-Efficient Economy Summer Study on Energy Efficiency in Industry.* Washington, DC: ACEEE.

[115] Association des Entreprises pour la Réduction de l'Effet de Serre (AERES), 2004. *Rapport 2003-2004: de la Première Période d'Engagement*, http://www.aeres-asso.org

[116] Swedish Energy Agency, 2005. *PFE – Program for Improving Energy Efficiency in Energy-Intensive Industries: Tax Exemption for Efficient Electricity Consumption*. Eskilstuna, Sweden: SEA. http://ies.lbl.gov/iespubs/PFE.2005.pdf

[117] Swedish Energy Agency, 2006. *The First Year with PFE: 2005 Report on the Programme for Improving Energy Efficiency in Industry.* Eskilstuna, Sweden: SEA. http://ies.lbl.gov/iespubs/PFE.2006.pdf

[118] Swedish Energy Agency, 2007. *Two Years with PFE: The First Published Results from the Swedish LTA Programme for Improving Energy Efficiency in Industry*. Eskilstuna, Sweden: SEA. http://ies.lbl.gov/iespubs/PFE.2007.pdf

[119] World Energy Council, 2004. 2004. Energy Efficiency: A Worldwide Review – Indicators, Policies, Evaluation. London: WEC.

prohibitively high transaction costs or complex and long procedures to process forms, international best practice is to restrict such grants or subsidies to certain types of investment, such as a selected list of equipment with a long payback time but high efficiency gains, or to investments of a certain size or level of cost-effectiveness.

Developing countries with higher risk market environments for investments may find that direct public funding in the form of grants or subsidies is a viable option for encouraging investment in energy efficiency. Public funds may also be needed where competition with more traditional investments such as infrastructure expansion receives most of the available financing, where non-asset based energy efficiency projects are perceived to be riskier than asset-based investments, where energy efficiency projects are too small to gain enough attention or where energy prices do not reflect real costs of energy and are too low for energy efficiency projects to procure enough financial benefit for individual companies.

Australia's Greenhouse Gas Abatement Programme (GGAP) targets all sectors of the economy but focuses on large scale emission reduction projects, especially those that exceed 250,000 tonnes of CO_2 equivalent emission reductions annually.[120] In the first two application rounds, 15 projects and almost $145 million were offered, with a goal of 27 million tonnes of GHG abatement.[121] In its subsidy program, Denmark prioritized the distribution of grants and subsidies to energy-intensive industries and companies involved in a voluntary agreement.[122]

Other subsidy schemes focus more on small- or medium-sized enterprises, which may not otherwise be able to afford to undertake large energy efficiency projects. The Netherland's BSET Program focused on small- or medium-sized enterprises, covering up to 25% of the costs for specific technologies such as heat recovery, heat pumps and absorption cooling.[123] The Scottish Clean Energy Demonstration Scheme (SCEDS) also focuses on small- to medium-sized businesses. SCEDS funds grants up to 80,000 GBP ($150,000 2005 U.S.) for development, demonstration, application and replication of energy efficiency measures and renewable technologies in Scotland.[124]

Some programs tie grants to a cost-effectiveness criterion. Thailand's Energy Conservation Program Fund (ECF), which was created in 1995 as a part of the Energy Conservation Promotion Program (ENCON) and is funded from a tax on petrol. ECF provides subsidies in both the public and private sectors, covering up to 50% of the costs for a facility up to 500,000 Baht (U.S.$12,000). In order for a facility to meet Thailand's

[120] http://www.greenhouse.gov.au/ggap/index.html

[121] Kemp, David of the Minister for the Environment and Heritage and Macfarlane, Ian of the Minister for Industry, Tourism and Resources, 2003. *Funding for Substantial Greenhouse Gas Abatement Projects.* Joint media release, May 29, 2003.

[122] Danish Energy Agency, 2000. *Green Taxes for Trade and Industry – Description and Evaluation*. http://www.ens.dk/graphics/Publikationer/Energibesparelser_UK/Green-tax-uk-rap.PDF

[123] Kræmer, T. Pipi and L. Stjernström, 1997. *Energy Policy Instruments – Description of Selected Countries.* Available at http://www.akf.dk/index_eng.html

[124] http://www.energy-efficiency.org/index.jsp

cost-effectiveness criteria, Thailand's program requires that each efficiency measure achieve an internal rate of return above 9%.[125]

Norway's IEEN program provides grants up to 20% in any sector investing in energy management or energy monitoring. Like Thailand, Norway also tied grants to cost effectiveness in its program that ran from 1990-1993, but Norway set a maximum limit on the rate of return as well as a minimum, from 7 to 30%.[126] From the 487 projects given a grant, a total of 1050 GWh/year was saved with a total investment of 1,200 million NOK ($188 million 2005 U.S.). Only 16.5% of these costs were IEEN subsidized (198 million NOK or $31 million 2005 U.S.).

9.3 Energy Efficiency Loans and Innovative Funding Mechanisms

Public (or soft) loans are loans subsidized by public funding that are offered at interest rates below market interest rates for investments in energy efficiency. The goal of subsidized loans is to promote energy efficiency measures until they achieve market acceptance level and can be funded on their own. According to the World Energy Council, public loans are less popular than subsidies in the countries surveyed.[127]

Innovative funding mechanisms aimed at increasing the involvement of banks and private capital in energy efficiency investments are also being used in some countries. In an effort to reduce public debt, trends show a movement toward these types of private sector, rather than the public sector, funds. By involving the private sector who seeks profits from their loans, these countries hope to develop a self-sustaining market in the long term, while obtaining a good return on investment in the short term.

Higher risk market environments that exist in developing countries and emerging economies may make it more difficult to raise financing from banks that tend to be conservative in investments, and who are not used to the idea of energy efficiency generating cash. Developing countries may also face competition with more traditional investments like expansion of industrial plants or power generation. In addition, energy efficiency projects without large capital investments are often perceived as riskier and/or are too small to attract multilateral financial institution lending.

Innovative funding mechanisms include equity participation through energy service companies (ESCOs), guarantee funds, revolving funds, and venture capital. ESCOs are private companies that provide project identification, engineering, design, installation, ongoing servicing and maintenance, monitoring and verification of savings, and/or financing of energy and energy efficiency projects. As a part of a private fund geared towards energy efficiency, the ESCO's role is to help to acquire and manage

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[125] Brulez, D. and R. Rauch, 1999. Chapter 4: Energy Conservation Legislation in Thailand: Concepts, Procedures and Challenges. In: Compendium on Energy Conservation Legislation in Countries of the Asia and Pacific Region. http://www.unescap.org/esd/energy/publications/compend/ceccpart2chapter4.htm.

[126] MURE II, n.d. MURE (Mesures d'Utilisation Rationnelle de l'Energie) Database. Available at: http://www.isis-it.com/mure/index.htm.

[127] World Energy Council, 2004. *Energy Efficiency: A Worldwide Review – Indicators, Policies, Evaluation.* London: WEC.

projects within the fund. According to the World Energy Council, economies in transition can especially benefit from ESCOs if initial funding can be raised or provided, although this experience is fairly recent.

With a few exceptions, such as industrial purchased steam or co-generation, ESCOs have had little impact on the development of energy efficiency projects that involve industrial systems. There are many reasons for this, including: high cost of opportunity identification and deal completion, limited replicability site to site, and lack of expertise in specific industries. ESCOs typically enter industrial markets with experience from the commercial sector and tend to concentrate on measures such as lighting and heating, ventilating, and air conditioning that are found in commercial buildings, which miss most of the energy savings at industrial sites. In recent years, suppliers of industrial system equipment have begun providing "value added" services that may include everything from a broader range of product offerings (sophisticated controls, drives, valves, treatment equipment, filters, drains, etc) to complete management of the industrial system as an outsourced provider. Their success appears to be attributable to their specialized level of systems skill and familiarity with their industrial customers' plant operations and needs.[128]

Guarantee funds provide a guarantee to the banks granting loans in the medium and long term. Many countries have guarantee funds, but these national funds are generally not adequate to support financing for energy efficiency projects and most of them have ceilings on the guarantees. In these cases, guarantee funds specifically for energy efficiency can be offered in addition to the national funds in order to cover credit risks associated with financing energy efficiency. To maximize their effectiveness, a good assessment of the potential benefits is key. France, Hungary and Brazil have all established guarantee funds for energy efficiency.[129, 130, 131]

With revolving funds, the reimbursement of the loans is recycled back into the fund to support new projects. These funds generally require public or national intervention to support them, either through subsidizing interest rates (low or zero) or by subsidizing the principal investment. They can be implemented at the local or national levels and can be applied to any sector. Thailand's Energy Conservation (ENCON) Promotion Act helped set up the ENCON Fund. The agreement to start the fund with six financial institutions was signed in 2003 with a total of 2 billion Baht ($50 million May 2005 U.S. equivalent). The fund is fixed for three years with the intention that at that point the scheme should become self-sustaining without the need for public intervention.

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[128] Elliott. R. Neal , 2002. *Vendors as Industrial Energy Service Providers*, American Council for an Energy Efficient Economy, Washington, DC.

[129] Agence de l'Environnement en de la Maîtrise de l'Energie (ADEME) website: http://www.ademe.fr

[130] Information on Hungary's program available through the International Finance Corporation at http://www.ifc.org/ifcext/eca.nsf/Content/SelectedProjectHungary?OpenDocument&UNID=F8F90E12332C17E9852569CF006E4CBA.

[131] World Energy Council, 2004. *Energy Efficiency: A Worldwide Review – Indicators, Policies, Evaluation.* London: WEC.

This trend has already begun, with more banks applying to become a part of the scheme.[132,133]

The UK's Carbon Trust is a government-funded independent non-profit organization that assists businesses and the public sector to reduce carbon emissions by 60% by 2050 as outlined in the UK Government's Energy White Paper.[134] The Carbon Trust provides interest-free loans to small- and medium-sized enterprises, funds a local authority energy financing scheme, promotes the government's Enhanced Capital Allowance Scheme, and has a venture capital team that invests between £250,000 and £1.5 million ($284,000 to $2.8 million 2005 U.S. equivalent) per deal as a minority stakeholder alongside private sector investors. VC investments include early-stage carbon reduction technologies as well as management teams that can deliver low carbon technologies.[135]

9.4 Tax Relief

Tax relief for purchase of energy-efficient technologies can be granted through tax exemptions, tax reductions, and accelerated depreciation. Such schemes are found in 22 countries.[136] A common approach is to provide a list of technologies for special tax treatment. Depending upon the specific program, this tax treatment could be: 1) accelerated depreciation where purchasers of qualifying equipment can depreciate the equipment cost more rapidly than standard equipment, 2) tax reduction where purchasers can deduct a percentage of the investment cost associated with the equipment from annual profits, or 3) tax exemptions where purchasers are exempt from paying customs taxes on imported energy-efficient equipment.

Accelerated Depreciation

Accelerated depreciation programs are found in Canada, Japan, The Netherlands, and Singapore. In Canada, the Accelerated Capital Cost Allowance Class 43.1 allows taxpayers an accelerated write-off at a rate of 30% for specified energy efficiency and renewable energy equipment instead of the standard annual rates of between 4% and

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[132] Energy Futures Australia Pty Ltd. and Danish Management Group (DMG) Thailand Co Ltd., 2005. Thailand's Energy Efficiency Revolving Fund: A Case Study. Prepared for Asia-Pacific Economic Cooperation Energy Working Group, July. http://www.reeep.org/media/downloadabledocuments/8/p/APEC%20-%20EE%20Revolving%20Fund%20-%20Thailand.pdf

[133] World Energy Council, 2004. *Energy Efficiency: A Worldwide Review – Indicators, Policies, Evaluation.* London: WEC.

[134] UK Department of Trade and Industry, 2003. *Our Energy Future: Creating a Low Carbon Economy*. http://www.dti.gov.uk/energy/whitepaper/ourenergyfuture.pdf

[135] Carbon Trust, 2005a *Develop Low Carbon Technology: Venture Capital*. http://www.thecarbontrust.co.uk/carbontrust/low_carbon_tech/dlct2_4.html

[136] World Energy Council, 2004. *Energy Efficiency: A Worldwide Review – Indicators, Policies, Evaluation.* London: WEC.

20%.[137] In addition, the program includes the costs of pre-feasibility and feasibility studies, negotiation costs, site approval costs, etc.[138]

In Japan, under the 1993 Energy Conservation and Recycling Assistance Law, an accelerated depreciation allowance equal to 30% of the acquisition cost is available for investments in heat pumps, floor heaters, CHP systems, district heating and cooling systems, high efficiency electric trains, low emission vehicles, energy-efficient textile manufacturing equipment, solar power systems, small- and medium-size hydro generators, and equipment for producing recycled paper and plastics.[139]

The Netherlands also provides the Accelerated Depreciation on Environmental Investment program (VAMIL), which allows an investor to more rapidly depreciate its investment in environmentally-friendly machinery, reducing operating profits and tax payments. This program has been in effect since 1991 and includes equipment that reduces water use, soil and air pollution, noise emissions, waste production and energy use. To qualify, the equipment must have relatively good environmental impacts, be not yet widely accepted in the country, have no negative side effects, and have the potential for a substantial market in the country. The list of qualifying equipment is updated regularly. Costs associated with obtaining advice on the purchased machinery are also subject to accelerated depreciation.[140, 141]

Under Singapore's Income Tax Act, companies that invest in qualifying energy-efficient equipment can write-off the capital expenditure in one year instead of three. Unlike the Canadian and Dutch programs, however, expenses related to acquiring information or consultant fees for identifying and analyzing the equipment purchase are not included in this program. Replacement equipment, such as new air-conditioning systems, boilers, and water pumps, along with energy-saving equipment such as high efficiency motors, variable speed drive motors, or computerized energy management systems qualify.[142]

Tax Rebates

Programs in which companies deduct the cost of energy-efficient equipment from their annual profits are found in Japan, South Korea, The Netherlands, and the UK.

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[137] Canada, Department of Finance, 2004. Background Information: Class 43.1 (Income Tax Regulations). http://www.fin.gc.ca/activty/consult/class431-2e.html

[138] Government of Canada, 1998. *Tax Incentives for Business Investments in Energy Conservation and Renewable Energy*.

http://www2.nrcan.gc.ca/es/erb/erb/english/View.asp?x=469&oid=111

[139] Anderson, D., 2002. Progress Toward Energy Sustainability in OECD Countries. Helio International. http://www.helio-international.org/Helio/anglais/reports/oecd6.html#top

[140] International Institute for Sustainable Development (IISD), 1994. *Accelerated Depreciation of Environmental Investments in the Netherlands*. http://www.iisd.org/greenbud/acceler.htm

[141] SenterNovem, 2005a. MIA and Vamil: *Tax Relief for Investments in Environmental Friendly Machinery*. http://www.senternovem.nl/mia/Topnavigatie/English.asp

[142] National Energy Efficiency Committee (NEEC), 2005. *Incentive Scheme: One-Year Accelerated Depreciation Allowance for Energy Efficient Equipment and Technology*. http://www.neec.gov.sg/incentive/home.shtm

Japan's Energy Conservation and Recycling Assistance Law also provides a corporate tax rebate of 7% of the purchase price of energy-efficient equipment for small and medium-sized firms.[143] In South Korea, a 5% income tax credit is available for energy-efficiency investments such as replacement of old industrial kilns, boilers, and furnaces; installation of energy-saving facilities, co-generation facilities, heat supply facilities, or energy-saving equipment; alternative fuel using-facilities; and other facilities that reduce energy by 10%.[144]

Tax Deductions

In The Netherlands, under the Energy Investment Deduction (Energie Investeringsaftrek, EIA) program, originally 40% and now 55% of the annual investment costs of energy-saving equipment can be deducted from the fiscal profit during the calendar year in which the equipment was procured, up to a maximum of €107 million. Qualifying equipment is provided on an "Energy List" and the costs associated with obtaining advice for purchased equipment can also be included. Approval is granted by SenterNovem, an agency under the Dutch Ministry of Economic Affairs. The budget for this program in 2005 is €137M.[145, 146]

The UK's Enhanced Capital Allowance Scheme allows a business to claim 100% first-year tax relief on their spending on qualifying energy-saving technologies specified in the "Energy Technology List" on their income or corporation tax return. Businesses can write off the entire capital cost of their investments in energy-saving technologies against their taxable profits for the year during which they make the investment.[147] The technologies that currently appear on the 2004 Energy Technology List are: air-to-air energy recovery, automatic monitoring and targeting, boilers, combined heat and power (CHP), compact heat exchangers, compressed air equipment, heat pumps for space heating, HVAC zone controls, lighting, motors, pipework insulation, refrigeration equipment, solar thermal systems, thermal screens, variable speed drives, and warm air and radiant heaters.[148]

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[143] World Energy Council, 2001. *Japan: Extract from the Survey of Energy Resources.* London: WEC. http://www.worldenergy.org/wec-geis/edc/countries/Japan.asp#top

[144] United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), 2000. *Promotion of Energy Efficiency in Industry and Financing of Investments.* http://www.unescap.org/esd/energy/publications/finance/index.html

[145] Aalbers, R.F.T., H.L.F. de Groot, and H.R.J. Vollebergh, 2004. *Effectiveness of Subsidizing Energy Saving Technologies: Evidence from Dutch Panel Data*, 6th IAEE European Energy Conference on Modelling in Energy Economics and Policy.
http://www.saee.ch/saee2004/Aalbers_DeGroot_Vollebergh_IAEE.pdf

[146] SenterNovem 2005b. *EIA: Tax Relief for Investments in Energy-saving Equipment and Sustainable Energy.* http://www.senternovem.nl/eia/Topnavigatie/English.asp

[147] HM Revenue & Customs, n.d. ECA – 100% Enhanced Capital Allowances for Energy-Saving Investments. http://www.hmrc.gov.uk/capital_allowances/eca_guidance.htm#claimingfya

[148] Carbon Trust, 2005b *The Enhanced Capital Allowance Scheme: Products and Claims*.
http://www.eca.gov.uk/etl/page.asp?pagecode=000100020001

Tax Exemption

A full exemption from Germany's petroleum tax is provided for highly efficient combined heat and power (CHP or cogeneration) facilities that have monthly or annual utilization rates of 70% or greater.[149] A Romanian program exempts imported energy-efficient technologies from customs taxes and exempts the share of company income directed for energy efficiency investments from income tax.[150] In November 2000, the Energy Efficiency Law was passed by the Parliament of Romania. The law covers the efficient use of energy in all areas. One element of the law is that "devices, machine tools, equipment and technologies for increasing energy efficiency are exempt of custom taxes".[151]

Companies that join Sweden's PFE program and comply with its requirements to carry out an energy audit and analysis of their facilities, introduce and apply an energy management system, establish and apply routines for purchasing and planning, and carry out energy-efficiency measures are exempted from the electricity tax of €0.5/MWh. Based on improvements planned for implementation by 2009 in 98 Swedish companies, tax exemptions of about €17 million will be realized by these companies through their participation in this program.[152]

[149] German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2004. *The Ecological Tax Reform: Introduction, Continuation and Development into an Ecological Fiscal Reform.* http://www.bmu.de/files/pdfs/allgemein/application/pdf/oekost_en.pdf

[150] Alliance to Save Energy, Municipal Network for Energy Efficiency, U.S. Agency for International Development, U.N. Economic Commission for Europe, n.d. *Survey of Energy Efficiency Laws and Policy Provisions in 22 Countries and Two Regions: Recommendations for Policymakers.* Washington, DC: Alliance to Save Energy.

[151] CEEBICNet Market Research, 2004. *Energy Efficiency in Romania.* http://www.mac.doc.gov/ceebic/countryr/Romania/EnergyEfficiency.htm

[152] Swedish Energy Agency, 2007. *Two Years with PFE: The First Published Results from the Swedish LTA Programme for Improving Energy Efficiency in Industry*. Eskilstuna, Sweden: SEA. http://ies.lbl.gov/iespubs/PFE.2007.pdf

10. Monitoring and Evaluation

Monitoring and evaluation guidelines for energy efficiency and greenhouse gas mitigation projects have been developed by numerous entities in order to understand the progress and results of specific projects. These include monitoring and evaluation components in the World Business Council for Sustainable Development and World Resources Institute's Greenhouse Gas Protocol Initiative,[153] the Global Reporting Initiative's Energy Consumption Protocol,[154] the U.S. Initiative on Joint Implementation, the World Bank's guidelines for the Global Environment Facility, the International Performance Measurement and Verification Protocol,[155] the U.S. Environmental Protection Agency's Conservation Verification Protocols, and the Dutch Long-Term Agreements.[156]

The project on Energy Audit Management Procedures within the European Union's Specific Actions for Vigorous Energy Efficiency (SAVE) Programme published a Topic Report on Monitoring and Evaluation in 2002 that provides an overview of the theory and practice of monitoring and evaluation along with specific examples from energy auditing programs in Finland, Denmark, France, The Netherlands, and Norway.[157]

10.1 Monitoring

It is extremely important to establish effective monitoring guidelines at the beginning of a project. Clear and transparent monitoring guidelines should be outlined that give enterprises an overview of what needs to be reported, when it should be reported, how it should be reported and to whom. Enough detail should be provided at the beginning of the project about how the project's savings or a particular piece of the project will be documented and what level of accuracy is desired. Ideally, monitoring also includes verification by an independent third party that will verify the submitted information and oversee the monitoring procedures. It is important to clearly define the monitoring process, outline the format and requirements of monitoring reports, and provide clear definitions regarding energy use and energy saving measures. According to the National Action Plan for Energy Efficiency, a monitoring and verification (M&V) plan should include the project description, inventories (where appropriate), description of the proposed measure(s), estimates of energy savings, a budget for M&V, and proposed construction and M&V schedules.[158] Any metering and analysis should be

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[153] World Business Council for Sustainable Development and World Resources Institute, 2002. *Greenhouse Gas Protocol Initiative*. http://www.ghgprotocol.org/

[154] Global Reporting Initiative, 2002. *Energy Consumption Protocol* http://www.globalreporting.org/GRIGuidelines/Protocols/EnergyProtocol.pdf

[155] http://www.evo-world.org/index.php

[156] Vine, E. and Sathaye, J., 1997. *The Monitoring, Evaluation, Reporting and Verification of Climate Change Mitigation Projects: Discussion of Issues and Methodologies and Review of Existing Protocols and Guidelines*. LBNL-40316. Berkeley, CA: Lawrence Berkeley National Laboratory.

[157] EU SAVE Programme, 2002. *Audit II Topic Report: Monitoring and Evaluation*. http://www.energyagency.at/publ/pdf/audit_moniteval.pdf

[158] Schiller, S. 2007. *National Action Plan for Energy Efficiency: Model Energy-Efficiency Program Impact Evaluation Guide*. http://www.epa.gov/solar/documents/evaluation_guide.pdf

designated to be performed consistently, logically and with accuracy acceptable to all parties. Details for key elements and an example M&V plan are given in the report.

The monitoring requirements of the Dutch Long-Term Agreements involved reporting on the energy-efficiency improvement achieved annually. Novem (later SenterNovem) outlined the monitoring requirements for the Long-Term Agreements in a Handbook.[159] The annual report included data on total energy use, the realized Energy Efficiency Index and progress on the projects carried out to reach the Energy Efficiency Index for that year. For example, the data required for the steel industry included total primary energy consumption for twelve types of steel end products, including four intermediate steel products (e.g. coke, sinter, pellets and pig iron). For each product step the energy consumption was converted into primary energy consumption and the energy intensity of each step was calculated. Corrections were allowed for changes in the mix of products, extra energy use as a result of stricter environmental regulations, and the degree of capacity utilization of existing product installations.[160, 161] The annual reports were submitted to an independent third party to check the reported values for accuracy and to calculate the Energy Efficiency Index on different levels of aggregation. The annual reports were then approved by a group composed of representatives of the steel industry, the government, and the independent third party.[162]

Companies that take part in the Dutch LTA2 are required to submit annual monitoring reports to SenterNovem on the progress they have made implementing their energy conservation plan (ECP). These corporate monitoring reports give companies a general view of how well they are succeeding in realizing their energy efficiency targets so that management can confirm the company policy or make an interim revision. SenterNovem uses the corporate monitoring report to assess whether a company is making enough effort to realize its ECP by evaluating the company's energy efficiency goals, the measures intended to be employed, and the schedule for reaching the goals. A corporate monitoring report provides a yearly insight into the company's progress with implementing the Long-Term Agreements, regarding the implementation of the ECP, distinguishing measures for each facility in process efficiency and the so-called *expansion* themes and the implementation of systematic *energy care* in the company. The report must provide data on the improvement in energy efficiency in the relevant facility/facilities compared to 1998 (the reference year), and the realized emissions reduction of CO_2. SenterNovem presents the LTA branch reports in a yearly brochure, thus providing an overview of the energy-saving measures taken by Dutch

[159] Novem, 1999. Handbook Energy Efficiency Monitoring of Direct Energy Consumption in Long-Term Agreements. http://www.senternovem.nl/mmfiles/hb_monitoring_tcm24-171841.pdf

[160] Hoogovens Technical Services, June 1992. *Energy Monitoring Hoogovens Ijmuiden: Calculation of the Energy Efficiency Index.*

[161] *Long-Term Agreement between the Association of Dutch Iron and Steel Producing Industries (NIJSI) and the Dutch Ministry of Economic Affairs concerning the Improvement of Energy Efficiency*, May 25, 1992.

[162] Nuijen, W., 2002. "Energy Efficiency Monitoring in Dutch Industry," Presentation at the *Workshop on Voluntary Agreements for China's Industrial Sector: Integrating International Experiences into Designing a Pilot Program*, February 25-27, 2002.

companies and the results they have achieved.[163, 164] An independent Benchmarking Verification Bureau monitors the covenant, verifying that each company has completed the different stages in the benchmark process, ensuring that the definition of the world lead is adequate, determining that the energy efficiency plan has been properly developed, and providing feedback on this to the company and to the competent authority.[165]

The UK Climate Change Agreements require that each entity report the total number of units of primary energy used during the target period for each type of fuel, the total number of units of carbon emitted from the target unit during the target period, the throughput during the target period, the information necessary to calculate the adjustment if the target is to be adjusted for product mix, and the information necessary to calculate the adjustment if the target is to be adjusted for emissions trading. The reports must be supported by information on how the calculations were made using spreadsheets supplied by the government. The UK Department for Environment, Food, and Rural Affairs provides detailed guidance, including spreadsheets, on Procedures for New Entrants and Exits / Changes to Facility Details, Accounting For Renewables, Performance Data and Auditing for the First Milestone, Combined Heat and Power Assessment Procedure, Handling Structural Change, Interface between Climate Change Agreements and Emissions Trading, How to Adjust Targets to Allow for Product Mix and Throughput Changes, and Converting electricity from dedicated supplies to primary energy.[166]

Besides annual verification and certification of the environmental management system (EMS), Danish companies that signed a voluntary agreement (VA) are monitored annually, through the obligation to submit progress reports. The progress reports should describe the status of the energy projects, the special investigations, and the EMS. The company must deliver the final report to the Danish Energy Authority.

Companies participating in the Japanese Keidanren Voluntary Action Plan perform annual surveys of their achievements, which are made public. In addition, the Advisory Committee on Natural Resources and Energy and the Industrial Structure Council also annually review the surveys submitted by the industries. Within Keidanren, there is also an Evaluation Committee that evaluates and provides feedback on the industry reports.[167]

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[163] For example the 2004 results can be found at: www.senternovem.nl/mmfiles/3MJAF05%2E03%20LTA%20Results%20for%202004_tcm24-175780.pdf

[164] A handbook energy efficiency monitoring of direct consumption in the LTA2s can be found on: www.senternovem.nl/mmfiles/hb_monitoring_tcm24-171841.pdf

[165] http://www.benchmarking-energie.nl/standaard.php3?pagid=326

[166] http://www.defra.gov.uk/environment/ccl/papers.htm#CCA

[167] Wakabayashi, M. and Sugiyama, T., 2007. "Japan's Keidanren Voluntary Action Plan for the Environment," in Morgenstern, R.D. and Pizer, W.A., eds, *Reality Check: The Nature and Performance of Voluntary Environmental Programs in the United States, Europe, and Japan*. Washington DC: Resources for the Future.

10.2 Evaluation

Evaluation is different from annual reporting and monitoring because it is undertaken only periodically to investigate why and how things happened within a program and to what extent this is the result of policies or other program activities. Evaluations assess programs to determine if they have met goals outlined at the initiation of the program as well as to assess what happened within the program. Evaluations done during the course of a program can provide recommendations to make adjustments and evaluations at the end of a project can identify lessons learned for the design of future programs. It is essential that evaluation guidelines and tools be determined early in the program.[168]

According to the National Action Plan for Energy Efficiency's Model Energy-Efficiency Program Impact Evaluation Guide, there are three types of evaluations of a program: impact evaluations, process evaluations and market effects evaluations. Impact evaluations determines how well a program did over a period of time or at the end of the program in terms of savings from technical, economic and market acceptance perspectives. These evaluations are then used to help redesign the program or design future programs. Process evaluations assess how efficiently a program was or is being implemented compared to its stated objectives, with the goal of learning lessons for future programs. Market effects evaluations estimate a program's future effects in the marketplace. The Model Energy-Efficiency Program Impact Evaluation Guide provides information and strategies for calculating energy savings and avoided emissions, as well as how to address issues like free-ridership, co-benefits and uncertainties. [169]

The University of Utrecht conducted a mid-program evaluation of the Dutch Long Term Agreements in 1997. The conclusions from this evaluation were that participation in the agreements generated more management attention to the energy situation in companies, participating companies became more aware of existing opportunities for energy saving, and consequently, the exploration of the existing potential was accelerated. The evaluation made the following recommendations for improvement: the quality and impact of the Energy Savings Plans needs to be improved, procedures need to be more uniform (energy savings plans, monitoring), targets could have been more ambitious, there should be more focus on long term developments, the impact of subsidies should not be overestimated, and there is room to extend the agreements to other areas. Based upon the positive evaluation of the agreements and the valuable recommendations, most parties expressed the desire to continue with the framework of Long-Term Agreements, taking into account that new elements would be added and some procedural improvements would be implemented.[170]

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[168] Schiller, S. 2007. *National Action Plan for Energy Efficiency: Model Energy-Efficiency Program Impact Evaluation Guide*. http://www.epa.gov/solar/documents/evaluation_guide.pdf

[169] Schiller, S. 2007. *National Action Plan for Energy Efficiency: Model Energy-Efficiency Program Impact Evaluation Guide*. http://www.epa.gov/solar/documents/evaluation_guide.pdf

[170] Nuijen, W. and Booij, M., 2002. *Experiences with Long-Term Agreements on Energy Efficiency and An Outlook to Policy for the Next 10 Years*. Utrecht, The Netherlands: NOVEM. http://www.senternovem.nl/mmfiles/lta_experiences_report_tcm24-171835.pdf

An evaluation at the completion of the first Long-Term Agreements used two methodologies – a bottom-up approach in which the actual outcome of the voluntary agreement was investigated by estimating the additional investments and related energy savings made by the manufacturing industry and a top-down approach which assessed the outcome of the agreements by comparing the monitored energy efficiency improvement with modeled, estimated efficiency improvements in a business-as-usual case. This evaluation concluded that "on average, between a quarter and a half of the energy savings in the Dutch manufacturing industry can be attributed to the policy mix of long-term agreements and supporting measures. In other words, the rate of energy efficiency improvement has increased by 33–100% compared with a situation in which there are no agreements. Apparently, then, the agreements are valuable policy instruments for energy efficiency improvement if accompanied by ambitious target setting, effective supporting measures and reliable monitoring procedures."[171]

In 2003 and 2004, an evaluation of the implementation and efficacy of the LTA scheme was conducted.[172] LTA2 proved to have had a positive impact on energy efficiency and an added value compared to other instruments such as energy taxes or CO_2 emission trading. In addition, the LTA2 program has positive side effects such as making companies aware of structural energy savings and forging better working relations between government and industry. Companies acquire more knowledge of the potential of realizing ambitious energy efficiency targets which results in above average process and product innovations. The participants of LTA2 conserve more energy than companies that don't participate.

The evaluation also showed some factors that could be improved that are outlined in an action plan. The plan contains the following key points:

- Process efficiency. Process efficiency contributes the most to the increases in energy efficiency. Continuous attention to process efficiency is necessary because new ways of improving process efficiency are developing all the time.
- Energy management. Most companies have incorporated energy management; however, not all the companies reach the same level. As a result of this evaluation the monitoring system and the checklist were simplified.
- Expansion themes. LTA participants show increasing initiatives as part of the expansion themes. It appears to be important that the participants are assisted in substantiating and realizing projects in the framework of the expansion themes. Furthermore it is necessary to monitor these projects.
- Cooperation. The cooperation between companies and the relevant Competent Authority should be improved.

[171] Rietbergen, M., Farla, J., and Blok, K., 2002. " Do agreements enhance energy efficiency improvement? Analysing the actual outcome of long-term agreements on industrial energy efficiency improvement in The Netherlands" *Journal of Cleaner Production* 10 (2002) 153–163.

[172] Center of Clean Technology and Environmental Policy of the University of Twente http://www.senternovem.nl/mmfiles/3MJAF05%2E03%20LTA%20Results%20for%202004_tcm24-175780.pdf

- Simplification. Research is currently being conducted to ascertain whether putting LTA into practice can be simplified, especially for small businesses, what would reduce the administrative burden and render the LTA process more efficient.

Within the framework of the European Intelligence for Europe Program, an evaluation of the Danish Voluntary Agreements on Energy Efficiency was carried out in 2006.[173] The conclusions from this study were that the agreement scheme addressed company-level barriers such as the lack of information. The agreements, particularly the elements of the Energy Management System (EMS), raised the awareness of energy efficiency at company level by putting energy issues on the agenda. The evaluation also showed that companies consider the EMS to be an important instrument in their effort to become more energy efficient. The positive view of the EMS is most common in the relatively large companies. One important factor to the successful implementation of the EMS is the similarity with other management systems, like environmental management system and the quality management system (ISO 9001). It was also found that the CO_2 tax addressed misplaced incentives in the industry since companies have relatively weak incentives for improving energy efficiency unless external costs for CO_2 emissions are accounted for by industry. The Danish evaluation also described that previous research (1999) showed that 34% of the energy savings resulting from specific projects would have been undertaken without the agreements, or conversely 66% of the investments were stimulated by the agreements.

The familiarity with the Energy Efficiency Agreements in Denmark is very high. This can be explained by the existence of an earlier simplified agreement scheme, in which the most energy-intensive companies took part. Because of this earlier scheme many companies already had contact with the Danish Energy Authority (DEA) who implemented and executed the scheme together with the Central Customs and Tax Administration. About 98% of the energy use in the heavy processes is covered by the agreements. The main benefit for the companies signing an agreement is the CO_2 tax rebate. Another important driver for the agreements is the reduction of energy costs resulting from the energy efficiency measures. Apart from economic drivers, there were also companies for which energy efficiency and agreements are part of their green profiling. These companies do often more than what the agreement requires.

In Japan's Keidanren Voluntary Action Plan, an Evaluation Committee comprised of academic experts was established in 2002 to assess whether the process for the collection, aggregation, and reporting of data in the industry annual reports is implemented properly as well as to make recommendations to improve the credibility and transparency of the reporting. Three evaluation reports have been produced by this committee in 2002, 2003, and 2004.[174]

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[173] Ericsson, K., 2006. *Evaluation of the Danish Voluntary Agreements on Energy Efficiency in Trade and Industry*. http://www.aid-ee.org/documents/011Danishvoluntaryagreements.PDF

[174] Wakabayashi, M. and Sugiyama, T., 2007. "Japan's Keidanren Voluntary Action Plan for the Environment," in Morgenstern, R.D. and Pizer, W.A., eds, *Reality Check: The Nature and Performance of Voluntary Environmental Programs in the United States, Europe, and Japan*. Washington DC: Resources for the Future.

11. Conclusions

This report provides detailed information on international experience related to the key elements of target-setting agreements. These key elements are the target-setting process, identification of energy-saving technologies and measures using energy-energy efficiency guidebooks and benchmarking as well as by conducting energy-efficiency audits, development of an energy-savings action plan, development and implementation of energy management protocols, development of incentives and supporting policies, monitoring progress toward targets, and program evaluation.

Target-setting agreements, also known as voluntary or negotiated agreements, have been used by a number of governments as a mechanism for promoting energy efficiency within the industrial sector. International best practice related to target-setting agreement programs calls for establishment of a coordinated set of policies and programs – such as those described in this report – that provide strong economic incentives as well as technical and financial support to participating industries.

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